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THE IRON AND STEEL INSTITUTE.

THE Iron and Steel Institute, although a very vigorous and influential, is still a comparatively juvenescent body. It was founded in 1869, "to afford a means of communication between members of the iron and steel trades upon matters bearing upon their respective manufactures," and this is done by holding periodical meetings for the purpose of discussing practical and scientific subjects having reference to these great industries. The first president of the Institute was the Duke of Devonshire, who was followed by Sir Henry Bessemer, F.R.S., the founder of the ingenious process and the important industry that bears his name. Since then the presidential chair has been occupied at two yearly intervals by the leading scientists and manufacturers in the trade.

The affairs of the Institute are controlled by a council of thirty members, selected from all the chief iron making districts in the United Kingdom, with some regard to the due and proportionate representation of each. The existing president is Mr. Daniel Adamson, the president, until he retired quite recently, of the Manchester Ship Canal Company. The secretarial office was filled for the first eight years of the life of the Institute by the late Mr. John Jones, and has been held for the last ten by Mr. J. S. Jeans, who is the author of several well known scientific and economic works. Since its establishment the Institute has held meetings at almost every important center of the iron and steel industries, both at home and abroad. Four meetings have been held on the Continent—where the Institute has many members: the first at Liege, the second at Paris, the third at Dusseldorf, and the fourth at Vienna. The Institute is holding its autumn meeting this year at Manchester, during the four days commencing September 14. The present membership of the Institute is about 1,400, and the last report of the council bore witness to the fact that, notwithstanding the extraordinary depression of the iron and steel industries within recent years, the membership steadily increases.

In the history of both national and international industry there have been few phenomena more remarkable than the progress and transformations that have marked the course of the industries which the Iron and Steel Institute represents. A few of the leading landmarks of this progress may be briefly indicated by way of illustrating the singularly important developments in which the Institute has borne a leading part.

The iron and steel industries embrace three leading departments or branches—pig iron, manufactured iron, and steel. Great improvements have been made in the first and the third of these, and their production has enormously increased. Manufactured iron, on the contrary, has been almost stationary as regards its processes of manufacture, while its use has been so far superseded by that of steel that its ultimate extinction is regarded as only a question of time. The principal changes that have occurred in the pig iron manufacture have been the increase of the height and capacity of the blast furnace, the use of higher pressures of blast, the utilization of the waste gases of the furnace for raising heat and steam, and otherwise, the introduction of more perfect types of stoves, engines, etc. These and other recent developments have enabled the maximum production of furnaces to be raised from 400 or 500 tons to upward of 1,000 tons per week, and this has been concurrent with an enormous economy of production as regards fuel and labor. In 1869, Great Britain imported hardly any ores for the iron manufacture. In 1882, we imported more than three and a half millions of tons, chiefly from Spain, and 15 per cent. of all the iron made in this country is now smelted from imported ores. It is, however, in the United States that the most remarkable developments have occurred. In 1869, that country only produced about one and three quarter million tons of pig iron. In 1886, the production was close on six million tons. Germany has also gone ahead with remarkable vigor, producing about three and a half millions of pig in 1886, as compared with 1,180,000 tons in 1869.

We must, however, inquire into the annals of the steel manufacture if we are to ascertain the real value of the great work that has been accomplished since the Iron and Steel Institute was founded. In 1869 the requirements of the world for structural purposes of all kinds were met by manufactured or wrought iron—a material produced with a very heavy expenditure of human toil and a great consumption of fuel—which has a fibrous texture, and, having its strength in one direction only, is liable to laminate and give way unequally. Bessemer introduced his remarkable process for the manufacture of steel in 1856. In 1869 not more than 350,000 tons of Bessemer steel were made in the whole world, and only 160,000 tons in the United Kingdom. In 1886, however, the production of such steel was close on 6,000,000 of tons. In the mean time Bessemer steel has been employed for a very great variety of purposes to which wrought iron was formerly put, and the extent of the economy thereby effected—as a consequence of the greater durability of steel—has been calculated at many millions.

Scarcely less important has been the new departure initiated by the late Sir William Siemens, a past-president of the Institute, whose now well known process for the manufacture of steel on the open hearth was then in embryo, whereas nearly a million and a half of tons are now annually produced, about one-half of which is turned out in the United Kingdom. It is impossible to trace here the various steps whereby this movement has been accomplished; nor can we give adequate expression to the enormous benefits that it has conferred upon the general public, alike as investors, as consumers, as railway travelers, as ship owners and ocean voyagers, and in a thousand other ways. The transformation that has been thus effected in the conditions of the manufacture and application of the useful metals is the best witness and the noblest monument to the useful career of the Institute, which the authors of that transformation have brought to its present highly prosperous and influential position.

Our portraits of the officers and council of the Iron and Steel Institute are from photographs.—*London Graphic.*

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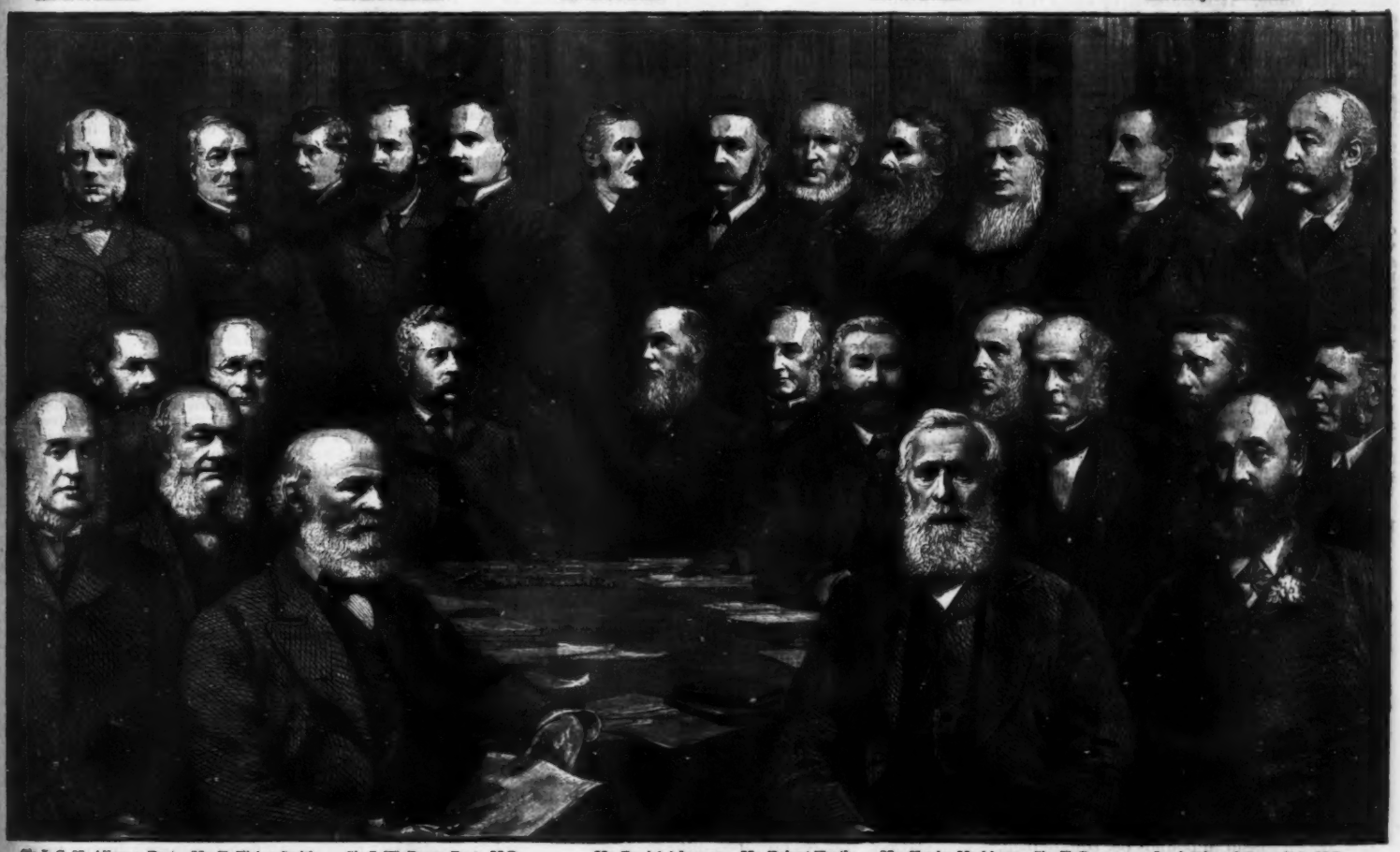

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OFFICERS AND COUNCIL OF THE IRON AND STEEL INSTITUTE.

THE TRANSMISSION OF NATURAL GAS LONG DISTANCES.*

By GEO. H. CHRISTIAN.

THE question of the pipage of natural gas long distances by its own pressure is one of great importance at the present time. We can hardly read a scientific paper that this subject is not spoken of, and various opinions expressed, but it is only by constant discussion that we can obtain a complete understanding of the subject and fully appreciate the future possibilities in this direction.

The practical questions of leakage, dangers from explosions, and the controlling of gas under high pressures have been solved by those working in this field, and I will give the facts as determined from practical working in Pittsburg and Allegheny City. I quote

* Read by request, February 8, 1887.

from results given to the public by the Philadelphia Co., Pittsburg.

"It being practically impossible to make a series of joints in the ordinary way that could be depended upon to remain gas tight, the attention of inventors and engineers was then directed to devising and perfecting suitable safety appliances, first to make the joints more secure, and second to confine within certain limits any escaping gas, and to conduct it through auxiliary pipes to places where it could escape safely. Such a system was perfected and applied to more than 100 miles of pipes in Pittsburg and Allegheny City, with most gratifying results. By its use the actual loss of gas by leakage is less than one per cent., and the danger of explosions from this source is, therefore, practically overcome. They have also devised the means of detecting and readily locating any leaks that may occur, without having to tear up the street to locate the same.

"Automatic pressure regulators have also been devised and patented, by which the pressure can be so accurately adjusted that the pressure of the gas as it enters the regulator through the inlet pipe may have a wide range of variation, but when it passes out of and beyond the regulator it will maintain a constant pressure of any degree required. Automatic shut-off valves and temperature regulators have also been devised." Mr. Bannister, in his book from which I have quoted above, closes as follows: "That the problems presented to the inventor and his coadjutors by the occurrence of natural gas have been completely solved must now be apparent to all. The pipe systems and appliances for insuring safety and preventing waste in its conveyance and distribution, and the devices for its perfect adaptation to every use as fuel, have been brought to such a high state of perfection that there is really nothing further to be desired."

It is left to us to but demonstrate the possibility of conveying this fluid in large quantities great distances by its own pressure, to induce capital to flow into this channel of trade. It is claimed by many that there is a limit in distance soon reached beyond which the cost of plant in proportion to quantity of gas delivered will render it impossible to give more than a few cities in this country the benefit of this fuel; and we see daily instances of the effect of this view in manufacturers moving their factories to places where natural gas is found in abundance. In an issue of *Van Nostrand's Magazine* can be found a scientific discussion on the flow of compressed air, and formula deduced almost identical to the water formula "for flow of water through pipes." This article is from the pen of Prof. Robinson, of the State University.

You will find his formula, derived from the principle of adiabatic expansion of gases, to exactly coincide with results obtained by a formula which I shall use, and which is derived from considering the work done by the expansion and friction of the gas. These facts, I believe, clearly prove the correctness of both. We will not go into the mathematics of this subject, but consider the forces acting when gas is flowing, and determine analytically the results.

Let us take a pipe of large diameter and great length, connected with a number of gas wells, allow this pipe to fill, and the terminal pressure to reach that at the wells. Now let us open a valve at delivery end, and ascertain the quantity discharged; which quantity will depend upon the following variables: the pressure of the wells and the length and diameter of your pipe line; the forces at work are expansion and friction, and it is the latter force we must determine.

From our knowledge of the flow of water through pipes, we have total head, H, in a line of pipe equals $h + h'$, where h is velocity head and h' friction head. Now these are the only losses on the supposition that the gas maintains constant temperature. We can then, having given the initial pressure, distance, and size of pipe, determine the friction loss and quantity discharged. In applying the formula for discharge you will find that the friction loss in uniform diameter pipe line increases in a rapid ratio as you approach the end of your line, and that to pipe gas with least outlay of plant, your pipe must be of variable diameter, and it remains to ascertain the degree of this increase. To do so, let us look at the equation of friction, which is written thus:

$$F = CH\frac{L}{D}S = F.$$

C = constant.
F = total friction.
H = velocity head in pounds per square inch.
L = length in feet.
D = diameter in feet.
S = coefficient of friction.

From this formula we see that the friction increases as the square of the velocity, inversely as the diameter of pipe, and directly as the length; also directly as the quotient of the pressure in pounds per square inch above vacuo divided by atmospheric pressure. Your pressure decreases as you advance from the wells, and your velocity increases. The density of your gas, however, decreases, so that your friction loss on this account will not increase as the square of the velocity, but more nearly as to the velocity. By increasing the diameter of your pipe to meet this increased velocity, and thereby maintaining a more constant velocity, you can keep your friction loss within small bounds.

To lay out a pipe line so that its friction losses shall remain within the pressure available, we have but to keep in mind this fact: that in steady motion the same weight of fluid must pass each cross section in a unit of time, whether your pipe is of uniform or variable diameter. Let us, then, take an example: Suppose we are required to determine the cheapest line of pipe possible to transport 225,000,000 cubic feet daily, and deliver the same at terminus of line 300 miles distant from the wells, having an available pressure at wells of 300 pounds per square inch. We will assume the initial diameter of pipe line to be 2 feet. A discharge of 225,000,000 cubic feet per day would be 2,600 cubic feet per second. The area of pipe 2 feet diameter is 3·1416 square feet. 2,600 divided by this area, 3·1416, equals 821. This divided by $\frac{314{\cdot}7}{14{\cdot}7}$ equals 39 feet per second as velocity in first mile, and from the formula for friction for gas specific gravity 0·6, the loss in friction for the first mile will be 5·2 pounds. Now if we should continue our pipe 2 feet in diameter for 10 miles, we should have a velocity in the tenth mile of 47 feet per second, and a friction loss of 6·4 pounds, making a total loss for friction in the first 10 miles of pipe 58 pounds, and will leave you a pressure at the eleventh mile of 242 pounds. Here let us increase to 2½ feet diameter and continue this diameter for 30 miles. Your velocity and friction loss in the first mile will be 30½ feet per second velocity, and 2 pounds per mile friction loss, and in the last mile of 2½ foot pipe velocity 41 feet per second, friction loss 2·76 pounds per mile, making a total loss of 70 pounds in the 30 miles, and leaving a pressure of 172 pounds at the forty-first mile point; here we will increase to 3 feet diameter and continue same 20 miles. Your velocity in first mile will be 29·3 feet per second, and friction loss of 1·15 pounds per mile, and in last mile of 3 foot pipe, velocity 34 feet per second, friction loss 1·38 pounds per mile, making a total loss of 25 pounds in the 20 miles, and leaving a pressure of 147 pounds at the sixty-first mile point; here we will increase to 3½ feet diameter, and continue same for 15 miles. The velocity in first mile will be 25 feet per second, and friction loss 0·6 pound per mile, and in last mile velocity 27 feet per second, friction loss 0·68 pound per mile; total loss in 15 miles, 10 pounds, leaving a pressure of 137 pounds at the seventy-sixth mile point; here we will increase to 4 feet diameter and maintain same to terminus of your line, or for 225 miles, and your total loss in that distance will be 136·8 pounds, leaving 0·2 pound pressure to maintain the flow of gas there of 207 feet per second.

Our pipe line beginning 2 feet in diameter and ending 4 feet will transport 225,000,000 cubic feet every 24 hours with an initial pressure of 300 pounds per square inch. This line, I believe, you will find to be the cheapest that could be built to do that work, but for other considerations it would be better to lay a double line of pipe, for the more perfect protection of your consumers in case of accident to one line. Having calculated for a pipe of initial diameter of 2 feet, we can readily ascertain what initial diameter would be required using two pipes to convey the same amount of gas, and you would find that two lines beginning 18 inches diameter and ending 3 feet will deliver nearly the same amount as the 2–4 foot single line will do. I wish to show you a peculiarity of these friction losses. Let us take a pipe 4 feet diameter and continue this diameter the 300 miles, and assume a discharge same as before, 225,000,000 cubic feet daily, what initial pressure would be required?

Beginning at the terminus and working backward, we shall find the losses thus:

1st to 6th mile	.....	6 miles	.....	14½ lb.
6th " 18th "	.....	12 "	.....	17 "
18th " 36th "	.....	18 "	.....	17 "
36th " 60th "	.....	24 "	.....	17 "
60th " 90th "	.....	30 "	.....	17 "
90th " 126th "	.....	36 "	.....	17 "
126th " 168th "	.....	42 "	.....	17 "
168th " 216th "	.....	48 "	.....	17 "
216th " 270th "	.....	54 "	.....	17 "
270th " 300th "	.....	30 "	.....	8½ "
300 miles.		Friction loss....		159 lb.

The friction loss remaining the same for every additional increment of 6 miles, thus you would need but 160 pounds of well pressure to transport 225,000,000 cubic feet daily 300 miles through a pipe 4 feet diameter throughout. Again, you can readily obtain total friction loss in any pipe line of constant diameter, length and pressure given. Assume a discharge, calculate the friction loss in first mile, multiply this friction loss by the number of times in density the gas in first mile is above atmosphere, add to this the friction loss in last mile, and divide this sum by $(\frac{PO}{P} \times 1)$. PO equals initial pressure above vacuo. P equals 14·7 atmosphere pressure. Thus, for last example: Terminal velocity 207 feet per second, initial pressure 159 pounds, $\frac{159+14{\cdot}7}{14{\cdot}7} = 11{\cdot}6$. The friction loss in first mile will be 0·3 pound. This multiplied by 11·6 equals 3·48 pounds. Friction loss in last mile 3·2 pounds; adding $3{\cdot}48 + 3{\cdot}2$ equals 6·68. $\frac{6{\cdot}68}{11{\cdot}6+1} = 0{\cdot}53$ pound as average friction loss per mile, and for 300 miles $0{\cdot}53 \times 300$ equals 159 lb. as before. This renders quite simple what would otherwise be a tedious calculation. Let us now look into the cost of our pipe line.

The average pressure in the 10 miles of 2 foot pipe would be 275 pounds. But since there would be times when the whole pressure of 300 pounds would be on the whole length of 10 miles, it should be made sufficiently strong to safely withstand the same. The thickness of said pipe should be, if of wrought iron or steel plate, ⅜ inch thickness, costing $25,000 per mile complete. The 2½ foot pipe would also have to stand 300 pounds pressure, and would have to be $\frac{7}{16}$ inch thickness, and cost $37,000 per mile. Here an automatic governor should be placed in your pipe, so as not to allow a greater pressure beyond this point than 225 pounds per square inch; for if the pipe line was doing its full capacity, the pressure would be but 172 pounds, and less on the 3 foot pipe. With 225 pounds pressure, thickness of pipe would be ⅜ inch and cost $37,000 per mile. Your 3½ foot diameter would require to be $\frac{7}{16}$ inch thickness, and cost $45,000 per mile. Here, again, an automatic pressure regulator should be placed to prevent the pressure beyond exceeding 100 pounds maximum, and your 4 foot would average in thickness throughout its entire length ¼ inch, and cost $30,000 per mile. This would make your pipe line net complete ten million dollars. Add to this the cost of right of way, gas property, drilling of wells, and city pipe system, and your total cost of plant would be nearly $16,000,000.

In the above estimate, I have assumed the pipe to be of wrought iron boiler plate, double riveted, and to be laid above ground, and arrangements made for the contraction which must take place when the gas is turned on, either by using expansion joints or laying the pipe in a wavy line.

There is another material that could be used, which, I think, would be even cheaper than riveted work, and that is open hearth or Bessemer cast steel pipe. This metal can be made in large amounts possessing a tensile strength of 60,000 lb. per square inch, and allowing a factor of safety of 10, you would have the same strength for each inch cross section as from a 3 inch cross section of cast iron, and the weight would thus be one-third lighter than cast iron, but heavier than boiler plate. These pipe ought to be made for 2¼ cents per pound, or even less for such large pipe. It is not my intention to go into the detail of cost, but simply to show that a pipe line can be laid to carry a large quantity of gas a great distance, and at a cost within bounds. At first sight, the sum of $16,000,000 might seem to be so great as to preclude capitalists from investing in such a scheme, but when we estimate the receipts from sale of this gas, we will probably change our minds.

One thousand cubic feet of natural gas contain 1,000,000 heat units; one bushel or eighty pounds of hard coal, 1,200,000 heat units. In burning gas for domestic purposes you realize 50 per cent. more of its heat than from burning coal, or your gas would be equal to 100 pounds of hard coal. Hard coal in New York City or Philadelphia is worth $5 per ton, or 25 cents per 100 pounds. If we should sell this gas for 12½ cents per 1,000 cubic feet, it would reduce the cost of fuel to the consumers 50 per cent. The daily receipts from sale of 200,000,000 would be $25,000, or $10,000,000 per year. Allowing fifteen per cent. on investment, you have remaining for yearly running expenses, improvements, repairs, and sinking fund, $7,750,000.

You may ask, How is it that you figure such a large revenue, when in Pittsburg their total yearly revenue is but $2,500,000? The facts are, in Pittsburg soft coal is used, and sells for $1.25 per ton, as against $5 in New York.

If you should pipe from Findlay Field to Chicago, you could not realize over 10 cents per 1,000 cubic feet, but even here $8,000,000 per year revenues should pay handsomely.

Cleveland and Cincinnati are both nearer the gas territory, and the cost of plant very much less. These places must very soon avail themselves of this cheap fuel.

It remains, in my opinion, but to determine the permanency of the supply of this fuel to induce capital into this channel of business, and we can look in the near future for the building of vast systems of pipe lines to all manufacturing centers in this country.

There is another question I should like to have this society consider, and that is to determine the quantity of gas discharged from an orifice under heavy pressures.

Professor Robinson, of this State, and others went to Findlay last summer to make some measurements of the gas wells, and in his pamphlet he gives several examples of the pressures and discharges of same, also a most interesting account of his experiments with the Pitot tube for measuring dynamic and static pressures, and showing the very great accuracy of the Pitot tube. He settled this point by his experiments—that outside of the plane of the orifice there was no static pressure, while inside there was both static and dynamic. In other words, at the plane of the orifice the static pressure becomes dynamic, and does work.

We will consider one of the examples given in his book, the Karg well. The pressure at the end of a 4 inch pipe when the valve was full open was 15 pounds per square inch. From this he calculates by the adiabatic formula the velocity of flow to be 1,513 feet per second, and as the area of 4 inch pipe is 0·0873 square foot, the discharge per second would be 132 cubic feet, or 12,000,000 cubic feet per 24 hours. What is this velocity in this case?

If we calculate the velocities of fluids of 0·6 specific gravity and 1·2 specific gravity, under pressures of 15 pounds per square inch, assuming each fluid as incompressible, the velocities would be 1,778 feet and 1,244 feet. If we add these and divide by 2, we have an average velocity of 1,511 feet per second. This is the average velocity of flow, but is it, as he makes it, the average velocity for a gas of 0·6 density? Is it not the velocity for a gas of average density between 0·6 and 1·2, which would make the discharge 18,000,000 instead of 12,000,000 cubic feet per day? That it is surely more than 12,000,000 I think I can clearly prove.

If the gas was incompressible and of specific gravity 0·6, its velocity of flow would be, under 15 pounds pressure, 1,778 feet per second, and quantity discharged 13,500,000 cubic feet.

From the formula $V = \sqrt{2gh}$ we have the velocity varies directly as the square root of the height, the height varies inversely as the densities, and therefore the weight of fluid flowing per second would vary inversely as the square root of the height. Thus a greater weight of fluid would flow per second from a pressure of one pound on water than from one pound pressure on air, or from one pound on gas of specific gravity 1·2 than from one pound on gas of specific gravity 0·6, and that this would be inversely as to the square roots of the heights, which in this case would be as $\sqrt{1} : \sqrt{2}$ or 18,000,000 cubic feet per day. Again, take gas specific gravity 0·6 under one pound pressure, velocity would be 456 feet per second. Assuming one square foot area of orifice and one cubic foot of gas, specific gravity 0·6 = one pound in weight, the weight of flow would be 456 pounds per second; gas at specific gravity 1·2 under one pound pressure, velocity would be 318 feet per second, and weight $318 \times 2 = 636$ pounds per second.

Calculated by the adiabatic formula, your velocity would be 430 feet per second, and by Prof. Robinson's method but 430 pounds, 26 pounds less than 456 pounds, which must be wrong. To me it would seem to be correct to calculate the velocity of flow due to pressure and density, multiply this velocity by the number of times the gas is in density greater than gas is at atmospheric density, then by area of opening, etc. Thus 15 pounds pressure its density would be 1·2 and velocity 1,244 feet per second, multiply 1,244 by $\frac{1{\cdot}2}{0{\cdot}6} = 2 \times 1{,}244$ we would have $2{,}488 \times 0{\cdot}0873 \times 86{,}400$, we would have 18,000,000 cubic feet discharge per day.

There is still another method of proof. Calculate the initial velocity by this formula where the length of pipe is quite short:

$$V_0 = \sqrt{\frac{g \times ch(P_0^2 - P_1^2)}{P_0^2 \left(\frac{4l}{d} + \log.\frac{P_0}{P_1}\right)}}$$

$g = 32$.
$a = 47{,}000$.
d = diam. in feet.
l = length in feet pipe.
s = coef. friction, 0·006.
P_0 and P_1 = initial and terminal pressures per square foot above vacuo.

The terminal pressure in this case is 15 pounds, or 29·6 pounds above vacuo. The initial pressure say for a length of 10 feet can be figured by calculating the friction loss in that distance. The following formula will give you the weight of the fluid flowing per second:

$$w = \frac{\pi}{4}\sqrt{\frac{g\, d^4\, (P_0^2 - P_1^2)}{\left(s\frac{4\,l}{d} + log.\frac{P_0}{P_1}\right) a}}$$

where $\pi = 3{\cdot}1416$.

If you will work this by this formula, you will find the weight of fluid flowing per second to be 9·6 pounds, which would be the weight of 210 cubic feet of gas, specific gravity 0·6, or a discharge of 18,000,000 cubic feet per day.—*Jour. Assn. of Eng. Societies.*

HYDRAULIC DRILLING MACHINERY.

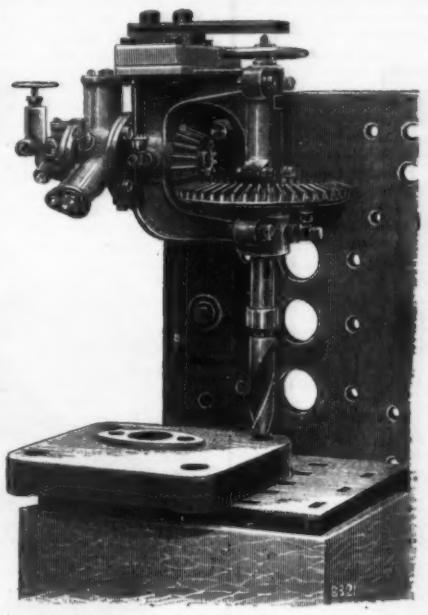
RECENT papers and discussions on the application of electric power to driving drilling machinery, at the best only leave the reader somewhat skeptical as to the economy, to say nothing of the practical feasibility of thus finishing *in situ* the great amount of drilling which cannot be done during the earlier stages of the construction of ships, bridges, boilers, etc.

No doubt, however, exists as to the practical success and the economy in working results when this drilling is done by hydraulic power. For some years past a great amount of work of this kind has been done in the French naval dockyards by the very neat hydraulic drilling engines of which we give two illustrations.

Between thirty and forty of these machines have been successfully introduced into France by Mr. Henry Chapman, of Paris. The illustrations are so clear that but little explanation is necessary, especially as we reproduced a paper read by the inventor, in our issue of February 11, 1887. In one arrangement a three cylinder engine is used for driving a drill direct. This is attached temporarily to a bracket, for drilling work —for example, on a vise bench—away from the shops. The whole affair is so light, weighing but 60 lb. or 70 lb., that it can be used in connection with an ordinary hand ratchet drill head. Hydraulic pressure at 1,500 lb. per square inch generally (but also sometimes at 750 lb. or 1,000 lb. per square inch) is conveyed to the drilling engine by means of special flexible copper tubing.

There is no more difficulty in attaching this gear to the plating on a ship's side than is experienced in the case of hand drilling, while the speed of working when once fixed is nearly 10 to 1 in favor of hydraulic work. In another application the drill head is still lighter, the power being transmitted from the engine to the drill by means of a Stow flexible shaft. The necessary speed for the flexible shaft is obtained by gearing up at the engine end and reducing again at the drill head. As shown on this illustration, only a very rough and ready bracket is required for the drill. The engine itself is simply placed on the scaffolding at the side of the ship. There is no risk here of the sudden disappearance of the whole apparatus below, since the attachment of the drill head is quite independent of the hydraulic pressure. In addition to the advantages obtained in the more accurate execution of the work, especially when several thicknesses have to be drilled in position, there is also the great saving in labor by reason of not having the plates, etc., to mark off, take to the shop, and put back in place again. The experience gained by the use of these drills on board large armorclads built on the cellular system goes to prove that 25 per cent. more holes can be drilled by them in the same time than can be done when the work has to be done in stationary machines in the shops, and that this class of work is done by them at seven times the speed obtainable by hand work.

For some time previous to M. Berrier-Fontaine reading the paper above referred to, Mr. Tweddell, of Westminster, had supplied some of his drilling machines to the Elswick firm for use on her Majesty's ironclad Victoria. They were very successful. One of these machines was used for drilling in the first place a 1 in. hole through two thicknesses of steel, 1½ in. and



¾ in., or 2¼ in. in all; the 1 in. hole having been put through, the drill was withdrawn and a hole knifed out to 3½ in. in diameter. These operations were completed in 12½ minutes, the time previously required by hand being fully three hours. A second machine was used for enlarging the holes from the inside to 5¼ in. in diameter through 2¼ in. thickness of steel. The machine had to be fixed in a most cramped position in the wings, and it being quite dark, all work had to be done by aid of the electric light. This machine did its work in one hour, as against nine hours by hand.

There is, indeed, a considerable field for the use of these drilling engines in workshops. In one boiler shop in the North of England the cost of drilling a large number of holes in boilers was at once reduced to 4d. per dozen instead of 1s. 4d., the cost by hand.

The type of engine used is the "Brotherhood" three-cylinder, with which our readers are sufficiently familiar. The probable extension of the use of hydraulic pressure for rotary engines was favorably discussed in connection with a letter addressed to this journal by the same engineer some time before on this subject.

It is not too much to say that from time to time in many branches of work "hydraulic machine tools" prove themselves to possess unexpected economical advantages, while their introduction by Mr. Tweddell has at the same time done much to relieve workmen of much unnecessary labor.—*Engineering.*

RIBBON INDUSTRY OF ST. ETIENNE.

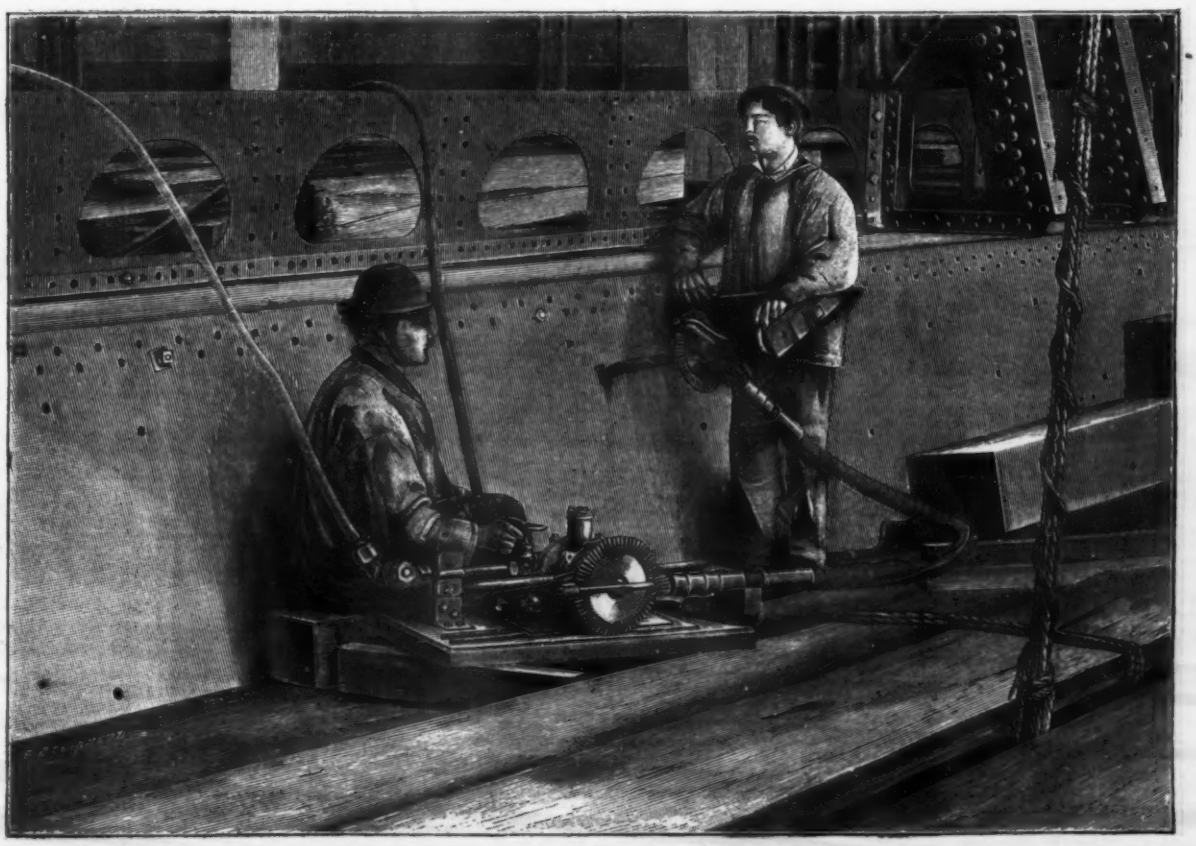
THE United States commercial agent at St. Etienne says that the ribbon industry, which was introduced into St. Etienne in the tenth century, was for a long time inferior to that of St. Chamond, where, at present, however, only special articles, such as braids, for example, are made. It is at St. Etienne exclusively that has existed for forty years the public test for silk destined to be manufactured into ribbons. The manufacture of velvets and ribbons absorbs annually from 5,000 to 6,000 kilogrammes of silk, representing a value of from 30,000,000 to 35,000,000 francs. The value of ribbons manufactured is from 70,000,000 to 80,000,000 francs.

The *rubanneris*, or ribbon industry of St. Etienne, is carried on by about 250 manufacturers, who are engaged in making many different articles, such as plain, black, colored, and figured ribbons, velvets, elastic goods, trimmings, braids, cravats, cords, galloons, etc. These manufacturers employ 18,000 looms and 50,000 workmen. The greater part of the looms of St. Etienne are worked by hand, and belong to the workmen themselves, who own small factories of from two to four looms. These looms are generally very well arranged, and perform the work well, and the manufacturers of St. Etienne, in view of the constant changes of fashion, find a great advantage in this arrangement. A manufacturer who creates a new article finds looms to produce it at a smaller cost than if he had extensive works and were obliged to exchange all his machinery. Looms for velvet generally belong to the manufacturer, as well as those for the fabrication of elastic ribbons, braids, etc.

It is estimated that the number of looms worked by steam or water power amounts to 2,000 or 3,000. There is no fixed rate of pay for workmen, as it varies according to the demand. Each ribbon requires a special agreement between employer and employe. While one man with a loom able to produce the article in vogue will gain from 10 to 20 francs a day, another with a loom producing a less fashionable fabric will make but 2 to 3 francs.

Until the year 1872, Mr. Coleman says that work was regular enough at St. Etienne, economical workmen grew rich, and most of the houses in the city were built by them, but since then the condition of the workmen has been less favorable, wages have been lower, and many have been out of employment. The ribbon production of St. Etienne formerly amounted to 110,000,000 francs yearly. This included braids also, which are now principally manufactured at St. Chamond. At the present day, the combined production of St. Etienne and St. Chamond is estimated at a sum not exceeding 90,000,000 francs. Until the year 1872, two-thirds of the ribbons manufactured were for exportation. At the present day those destined for exportation do not exceed one-third.

IN some parts of Germany and Austria, natural pumice stone has been superseded by an artificial stone, to which a suitable shape can be given and different degrees of fineness of grain obtained, which allows the stone to be used in all the industries where natural pumice stone was formerly employed. The ingredients are white sand, feldspar, and fire clay, mixed in suitable proportions to obtain the desired composition, and the paste is poured into plaster moulds, being finally placed in fire clay receptacles and baked in ovens.

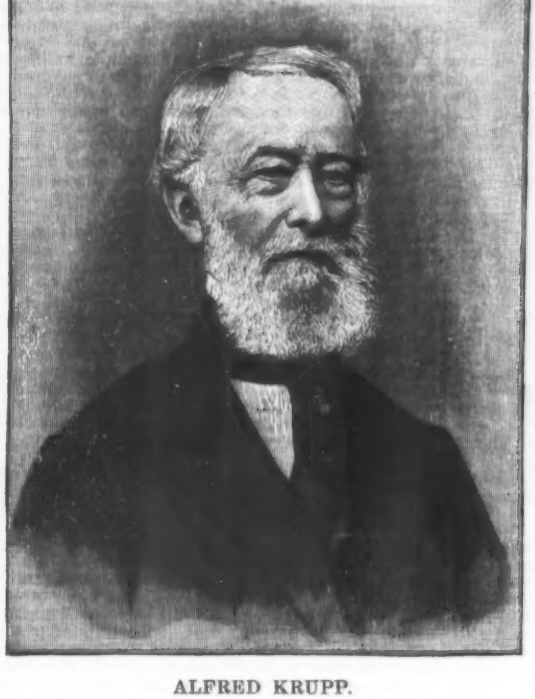


PORTABLE HYDRAULIC DRILLING MACHINES AT TOULON DOCKYARD.

KRUPP'S GREAT GUN FOR THE ITALIAN NAVY.

THE great German manufacturer of steel and of the most powerful artillery, Herr Alfred Krupp, who died on July 14, had in hand at Essen, for two years past, a gun constructed for the Italian navy, which is the largest hitherto produced. We give an illustration of this huge piece of ordnance, as it appeared when placed on a special railway wagon for conveyance to Antwerp, where it was put on board ship to be carried round into the Mediterranean, consigned to the Italian naval arsenal at Spezia.

The railway truck, built expressly for this purpose, was 75 ft. long, with thirty-two wheels and sixteen axles; but its length could form bendings, at six points, to pass round curves on the line of rails; this carriage, without its load, weighed ninety-six tons. The gun, which weighs a hundred and eighteen tons, is 45 ft. long, and its internal caliber is nearly sixteen inches, rifled with ninety-two spiral turns. It throws a steel projectile weighing nearly one ton, with a charge of six cwt. of brown prismatic powder, having an initial velocity of 614 yards in a second and a range of nearly eight miles. The shot can penetrate a steel armor plate thirty-six inches thick immediately at the mouth of the gun, and a plate twenty-nine inches thick, it is estimated, at the distance of a mile or more. It is believed that no armor-plated ship in the world can endure the fire of such powerful guns. Krupp's factory, however, is now engaged in making two of still larger dimensions.—*Illustrated London News.*

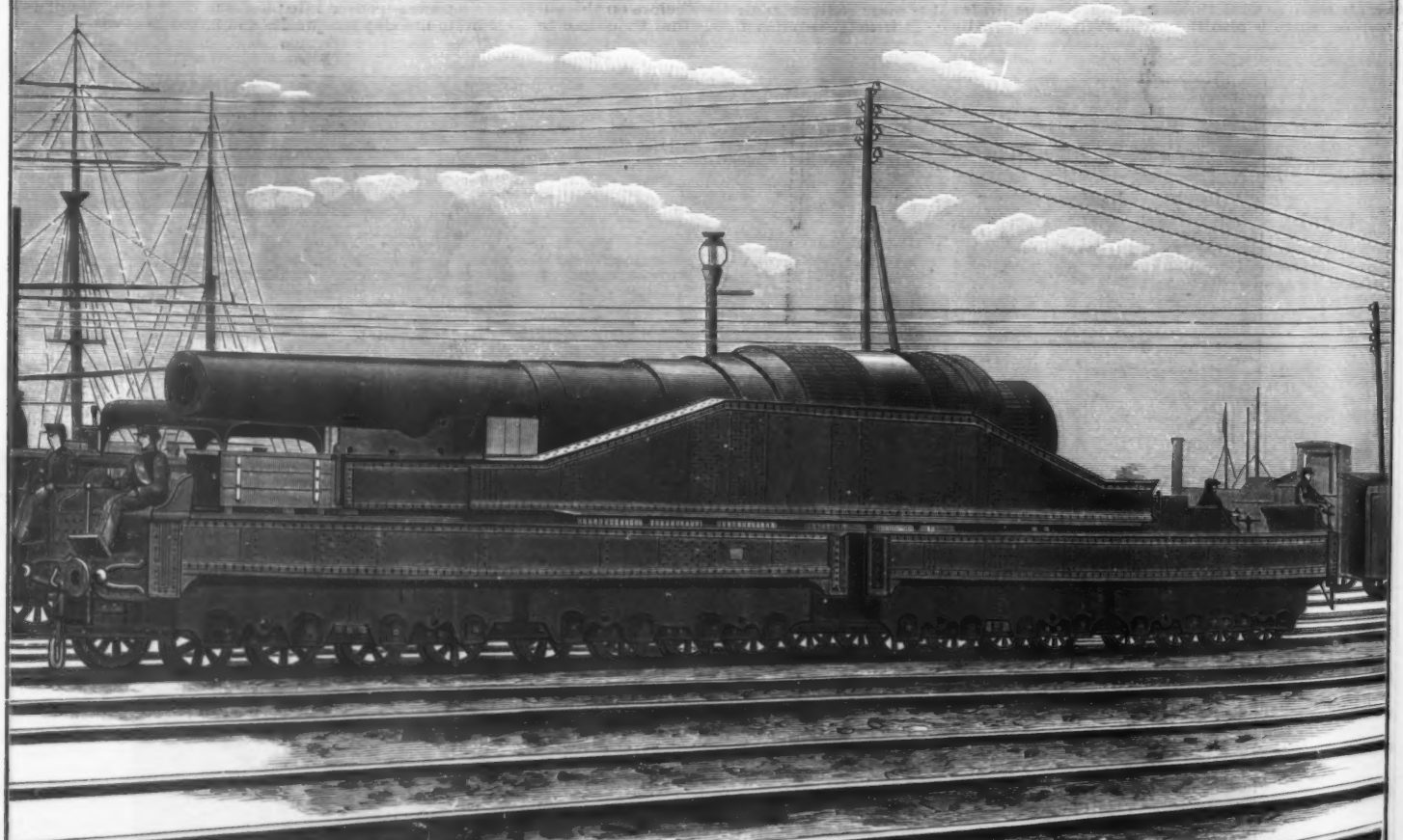


ALFRED KRUPP.

ALFRED KRUPP.

ALFRED KRUPP.

GERMANY was fortunate in finding, at one of the most critical periods of her history, just the men she needed to establish her supremacy among nations; and among these men, Alfred Krupp, who died July 14, was preceded by only the Emperor, Bismarck, and Moltke. To him and Dreyse, the inventor of the needle gun, Germany is indebted for her weapons; and to him, before all others, together with the excellent leadership and masterly organization of the Prussian-German army, are the three victorious campaigns due which founded the unity and power of Germany. With the modest pride of the *burger* he never sought recognition, being satisfied to do his duty and to use



KRUPP'S LATEST GREAT GUN, PLACED ON THE RAILWAY EN ROUTE TO ITALY.

his power to the utmost for the good of mankind. Posterity will not forget him, for he will be known not only as the "Cannon King," but also as the "Man of Peace." All of his energy was not turned to the manufacture of guns, much attention being given to the production of steel rails and other railroad supplies, as well as to heavy forged pieces of steel and iron. The firm of Krupp ranks among the best manufacturers of rails in the world, and is one of the most dangerous competitors of Belgian and English concerns. Krupp's arrangements for the welfare of his workmen and their families at Essen are models for the world. He died with the knowledge that his life had been successful, for he had brought blessings to all with whom he had come in contact. Alfred Krupp was born April 11, 1812, and was, therefore, seventy-five years old when he died. His father, Friedrich Krupp, was the inventor of cast steel, but the son perfected the invention. Friedrich Krupp died in 1826, and the works at Essen did not attain their highly prosperous condition until 1851.

So much has already been written about the life of Alfred Krupp that it would be like carrying coals to Newcastle to say more now. So we will only allude to the ability with which he arranged his establishment, providing himself with a corps of excellent assistants, so that the work of his life could be continued after his death. For this purpose he obtained a public loan of $7,500,000, which was, however, paid April 1, 1886. Another proof of the immense wealth of Alfred Krupp is the fact that he paid larger taxes than any one else in Prussia.—*Ueber Land und Meer.*

KRUPP'S EARLY HOME.

SURROUNDED by tall chimneys, which belch out dense columns of sooty smoke, and by hundreds of huge buildings and the rush and roar of the great works of Essen, Rhenish Prussia, which owe their present extensive existence to Alfred Krupp, who has just died, stands the little house in which this master workman was born, a cozy, unpretentious little structure, which the great gun maker guarded as one of his most precious possessions. He looked upon it, when compared with its surroundings, as a more suggestive monument than letters of nobility, for it is a monument not only to Alfred Krupp, but to democracy, genius, and industry.

The iron king of Germany had this little house photographed, and the pictures were distributed among his 20,000 workmen some years ago. The inscription accompanying these photographs is as follows:

"Fifty years ago this primitive dwelling was the abode of my parents. I hope that no one of our laborers may ever know such struggles as have been required for the establishment of these works. Twenty-five years ago that success was still doubtful which has at length—gradually, yet wonderfully—rewarded the exertions, fidelity, and perseverance of the past. May this example encourage others who are in difficulties! May it increase respect for small houses and sympathy for the larger sorrows they too often contain! The object of labor should be the common weal. If work bring blessing, then is labor prayer. May every one in our community, from the highest to the lowest, thoughtfully and wisely strive to secure and build his prosperity on this principle! When that is done then will my great desire be realized.

"ALFRED KRUPP.

"Essen, February, 1873.
"Twenty-five years after my taking possession."

THE GENERATION OF STEAM.

IN our SUPPLEMENT No. 616 will be found an article on "Combustion." The following article may be regarded as a sequel to it. Like it, it is intended for the perusal of non-scientific men and students.

It will be remembered that, when writing on combustion, we explained how much heat can be got out of a pound of coal. We now propose to show what becomes of that heat in the process of generating steam. To make what follows clear, it will be necessary to say something of specific heat and latent heat.

We have already explained that the thermometer can only measure *temperature* or intensity. It cannot measure *quantity*. For example, it is obvious that there must be twice as much heat in two pounds of boiling water as there is in one pound; but a thermometer first put into a vessel containing one pound and then into another vessel containing two pounds will still give the same indication, viz., 212°. Now, different bodies have different capacities for heat, or, in other words, their specific heat varies. That is to say, if we bring two different bodies to the same temperature, the quantity of heat in each will vary. Water has the highest specific heat of any known substance, gas, or liquid, and is therefore taken as a standard. The following table gives the specific heat of a few well known metals, water being taken as unity:

Lead	0·03084
Gold	0·03244
Mercury	0·03332
Tin	0·05695
Silver	0·05701
Copper	0·09515
Zinc	0·09555
Wrought iron	0·01218
Steel	0·11650
Cast iron	0·12983

To find the quantity of heat necessary to raise any of these metals to a given temperature, it is only necessary to multiply the quantity of heat required to raise an equal weight of water to the same temperature by the fraction given above. Thus, for example, let it be required to ascertain the quantity of heat necessary to raise say 10 lb. of cast iron 100°. We know that the quantity of heat required to raise 10 lb. of water 100° is $10 \times 100 = 1{,}000$ thermal units. Then $1{,}000 \times 0{\cdot}12983 = 129{\cdot}83$ thermal units. In round numbers, the specific heat of water is about eight times as great as that of cast iron.

Gases have in like manner their specific heats. The specific heat varies with the pressure under certain conditions, but with this we have at present nothing to do.

Nor need we concern ourselves with the specific heat of any gas but air, which is 0·23. In round numbers, 1 lb. of water requires four times as great a quantity of heat to raise it to a given temperature as does a pound of air.

It has already been shown in the article on combustion that a pound of coal properly burned will give out about 14,500 thermal units, and that it requires for its combustion 18 lb. to 24 lb. of air. The first effect of the burning coal on the grate is to raise this air to a very high temperature; but as the air passes through the tubes or flues of the boiler, it surrenders a large quantity of this heat. We may, therefore, neglect the furnace temperature and deal only with that of the gases as they leave the boiler. A very common temperature is 500 deg. If the air entered at 60 deg., then it is clear that, going away to the chimney at 500 deg., it has been raised by the coal through 440°. The total quantity of heat wasted up the chimney per pound of coal will be found by multiplying the number of pounds of air admitted to the furnace per pound of coal by the elevation in temperature and by the fraction 0·23 representing the specific heat of air. We have then for 18 lb. of air, $18 \times 440 \times 0{\cdot}23 = 1821{\cdot}6$, and if 24 lb. of air are admitted, we have $24 \times 440 \times 0{\cdot}23 = 2428{\cdot}8$. From this it will be seen that the more air we admit to the furnace, the greater the waste; but care must be taken not to admit too little, otherwise, as has been explained in the article on combustion, there will be still greater waste caused by the imperfect burning of the coal.

Of the 14,500 thermal units given out by the coal, then, we see that about 2,000 are wasted up the chimney, unavoidably, leaving us only 12,500 to make steam with. It is to save some of this waste heat that "economizers" are employed. These are pipes set in an enlargement of the flues, and through them the cold feed water is pumped, and so raised in temperature. The object of all economical boilers is to send away the escaping gases at as low a temperature as possible, but this can never be less than that of the water in the boiler.

We have now to consider the work done by the 12,500 units remaining to us in generating steam. The first work is to raise the feed water to the boiling point, which varies with the pressure, increasing as the pressure increases. The following table gives a few of the more usual pressures and temperatures:

Absolute Pressure per sq. in. Lb.	Temperature, Deg. Fah.
14·7	212
20	228
30	250
40	267
50	281
60	293
70	303
80	312
90	320
100	328
150	358
200	382
250	401

The safety valve loads will always be 14·7 lb.—in round numbers, 15 lb.—less than these, because the pressure of the atmosphere loads the valve. Thus, 100 lb. in the preceding table corresponds with a pressure as shown by the pressure gauge of 85 lb. The feed water goes on rising in temperature till it attains the temperature proper to the pressure. Then it begins to boil, not before. Let us suppose, for the sake of illustration, that we have a boiler working at 85 lb. by the gauge; the boiling point is 328 deg. Let the feed be pumped in at 60 deg.; then each pound of it will require 328—60 = 268 thermal units to raise it to the boiling point. Once this is reached, the water gets no hotter. The heat is thenceforth expended, not in augmenting temperature, but in making steam, and is said to become "latent," or hidden. This expression is not strictly correct, but as it is commonly used it may be allowed to pass. Thus, then, each pound of steam contains what may be regarded as two quantities of heat—one quantity expended in raising temperature, the other in converting the water into steam. Now, it is a noteworthy fact that the sum of the sensible and latent heats of steam is very nearly constant under all circumstances. Thus, let us take steam at atmospheric pressure, as, for example, it comes from the spout of a tea kettle. Its sensible temperature is 212 deg., representing 212 thermal units per pound; its latent heat is 965 deg., representing 965 thermal units per pound, and 212 + 965 = 1,177 thermal units per pound, measured from zero. Steam 100 lb. pressure—85 lb. by the gauge—has a sensible temperature of 328 deg., representing 328 thermal units, a latent heat of 883 thermal units, and 328 + 883 = 1,211 measured from zero, which, it will be seen, is only 34 deg. in excess of the sum of the latent and sensible heats of steam at 212 deg. The total number of units of heat which have to be used in making a pound of steam will vary with the temperature of the feed water. Let that be 60 deg. Then each pound of steam at 100 lb. pressure represents 1,211 — 60 = 1,151 thermal units. We have seen that all the heat left in after the air necessary for combustion has had its share is 12,500 units per pound of coal. Then $\frac{12{,}500}{1{,}151} = 10{\cdot}86$ lb. as the greatest possible weight of water that can be converted into steam of 100 lb. absolute pressure; if the admission of air is at the rate of about 22 lb. of air per pound of coal, and if the temperature of the escaping gases is 500 deg. With the data here given our readers can calculate for themselves the return to be expected under other conditions of pressure, temperature, weight of air admitted, and so on.

It must be remembered, however, that there are other sources of waste, concerning which we have said nothing. One is found in the fact that coal is not all combustible. It contains a greater or less weight of ash, which is simply incombustible mineral matter, and varies very greatly in quantity with the quality of the coal. Some of the best Welsh coals contain hardly any incombustible matter; on the other hand, lignite or brown coal, much used on the Austrian railways, contains so much light ash that after a run of twenty-five miles or so the smoke boxes of the locomotives become half filled and have to be cleared out. Another source of waste is bad firing, which causes unburned coal to fall through the bars. Lastly, a great deal of heat is radiated from the boiler and the brickwork in which it is set. It is to prevent this loss that boilers are clothed. It does take place, however, and in some cases represents a good deal. When all these things are put together, it will be seen that large deductions must be made from the total quantity of heat set free by combustion, and a boiler which can evaporate 10·8 lb. of water from feed at 60 deg. must be exceptionally excellent. What we have said indicates that economy is to be sought, first, in securing the complete combustion of the fuel and the gases it liberates; secondly, in admitting the smallest quantity of air which will suffice to secure perfect combustion; thirdly, in sending away the gases from the boiler at a temperature as near as possible to that of the water in the boiler; fourthly, in using the gases, after they have left the boiler, to heat the feed water; fifthly, to prevent in every way possible the radiation of heat from the boiler; and lastly we may point out that considerable advantage might be derived from heating the air required for combustion before it enters the furnace, if only it could be done cheaply and in a satisfactory way. The effect of heating it would be analogous to that produced by heating feed water, and may be calculated in the same way.

No attempt has been made to go into minute detail, but enough has, we think, been said to give a sufficiently precise idea of the principles involved in the generation of steam, and to enable the non-scientific reader to make for himself the few simple calculations necessary to estimate the possible efficiency of a steam boiler and its furnaces.—*Q., The Engineer.*

[Continued from SUPPLEMENT, No. 616, page 9840.]

[FROM THE AMERICAN JOURNAL OF SCIENCE, 1887.]

ON RED AND PURPLE CHLORIDE, BROMIDE, AND IODIDE OF SILVER; ON HELIOCHROMY AND ON THE LATENT PHOTOGRAPHIC IMAGE.

By M. CARY LEA, Philadelphia.

IDENTITY OF THE PHOTOSALTS OF SILVER WITH THE MATERIAL OF THE LATENT PHOTOGRAPHIC IMAGE.

IN the first part of this paper, I described certain strongly colored forms of silver chloride, bromide, and iodide, obtained independently of any action of light, for which I proposed the name of photosalts, by reason of their identity with the products of the action of light on the normal silver haloids, both with the substance of the latent image itself and also with the principal results of the continued action of light on these haloids. It remains to prove this identity.

First as to identity with the product of the continued action of light.

If we expose silver chloride precipitated with excess of HCl to light, we get a deep purple black substance which, boiled with dilute nitric acid, gives up a little silver, at the same time somewhat lightening in color and forming a dull purple material which closely resembles some of the forms of photochloride described in the first part of this paper, most those produced by the action of sodic hypochlorite or of ferric chloride on metallic silver—it shows the same reactions with ammonia that they do. The brighter colored photochlorides are not formed by the action of light on silver chloride.

But these brighter colored chlorides can also be shown to be formed through the action of light. Most salts of silver darken by exposure, and when these dark products are treated, first with HCl, and then, after thorough washing, are boiled with dilute nitric acid, we can obtain results perhaps as varied as those which I described in the former part of this paper as arising from purely chemical action.

Silver oxalate exposed for two days to sunshine, covered with water and with frequent agitation, changed to a deep brownish black which by treatment with HCl became a little lighter. When this product was washed and boiled with strong nitric acid, it acquired a fine deep copper red color, the acid taking up silver. This red substance dissolved in ammonia readily, leaving a small amount of black residue—the same with sodium hyposulphite.

(This examination, made a year ago, has recently been repeated with a view to obtaining a quantitative determination of the proportion of Ag_2Cl contained in the red product. The exposure was for about a day; the oxalate at the end of the exposure seemed absolutely black. After treatment with HCl it assumed a purple black shade. After thorough washing and boiling with dilute nitric acid, which removed a large quantity of silver, perhaps 12 or 15 per cent. of the entire quantity, it had a fine lilac purple color. Analysis showed that it contained about one-half of one per cent. of subchloride, or, more exactly, 0·45 per cent. Ag_2Cl was found.)

The red chloride thus obtained from silver oxalate not only closely resembles the red chloride obtained by means exclusively chemical, but shows the same behavior to reagents.

Treated with ammonia, it dissolves, leaving a black residue. The formation of this residue takes place precisely in the same manner with both substances. As fast as the material dissolves, the liquid becomes clouded and an extremely fine black substance seems to form within it, which gradually falls to the bottom.

Treated with solutions of the alkaline haloids, the red chloride derived from exposed silver oxalate remains unchanged after twenty-four hours' contact with potassic chloride, and becomes paler and more lilac under potassic bromide—under potassic iodide becomes gray. These reactions correspond with those of the photochloride.

Silver phosphate belongs to the more sensitive silver salts, and easily darkens in sunlight. In a few hours it becomes greenish all through, after which further exposure produces little visible effect. This product becomes with HCl quickly gray, and by treatment with nitric acid after washing, light pink.

Silver tartrate by exposure to sun became quite black. With HCl this changed to reddish gray or dull pink. This product well washed and let stand with cold nitric acid 1·36 became first lavender and then light pink.

Silver carbonate by prolonged exposure became greenish black, and with the above treatment yielded a dull pink photochloride.

Silver pyrophosphate even by several days' exposure

to winter sun did not blacken, but assumed an ocherous or buff shade. With HCl this passed to a sort of salmon pink, and by heating a few minutes with dilute nitric acid, to a beautiful copper shade.

Silver acetate was singularly little affected by sunlight. It looked blackish, but on closer inspection was found to be very little altered. By the same treatment as above it yielded a pale pink photochloride.

So far as examined, all silver salts thus treated yielded pink or red photochloride.

These facts may serve to show the identity of the photochloride with the principal product of the continued action of light on silver chloride and on other salts of silver, subsequently converted into chloride. I should wish, however, to use this word identity in a somewhat limited sense. When the photochlorides are formed by different methods without the aid of light, hardly any two forms can be considered absolutely identical. They differ in color and in proportion of subchloride, as already often mentioned, but they also differ in other respects, especially in resistance to reagents. Some forms are far more easily destroyed by nitric acid. Those obtained by the action of sodium hypophosphite (as presently to be described) are among the most easily destroyed by nitric acid. There is variation, too, in the degree of their resistance to ammonia.

Very similar differences are found in the stability of the photochlorides obtained by the action of light. Some are much more readily attacked by nitric acid than others. The product obtained by the action of light on silver chloride resists ammonia more strongly than that obtained by the action of HCl on exposed silver oxalate. This last is quickly attacked. Generally, I think the dark colored forms are the most stable.

At a future time it may perhaps be possible to distinguish more exactly between these varieties.

I next pass to the consideration of the identity existing between the photosalts and the material of the latent image. Before entering, however, on that matter, it is necessary to describe a reaction leading to the formation of these photosalts, somewhat differing from the reactions already mentioned, and which has important bearing on the subject.

The remarkable action which an alkaline hypophosphite exerts on salts of copper was described many years ago by M. Wurtz. Its action on silver salts, though there is no parallelism between the two, has enabled me to find a key to some of the great difficulties of the latent image.

A dilute solution of sodium hypophosphite if poured over a mass of chloride, bromide, or iodide of silver formed in the absence of light, produces no visible effect, but has the property of bringing those substances into the condition in which they exist in the latent image. Applied in strong solution and with the aid of heat, it produces brown purple photochloride, bromide, and iodide of silver. I will here briefly describe the first of these compounds in order to continue the series of photochlorides, and then pass to the consideration of the latent image.

Photochloride of Silver by Sodium Hypophosphite.

Silver chloride freshly precipitated with excess of HCl and well washed, placed in a flask with a strong solution of sodium hypophosphite and heat applied, begins to darken before the boiling point is reached. Actual boiling for ten or fifteen minutes gives a deep chocolate color. This product well washed and freed from traces of metallic silver by cautious boiling with very dilute nitric acid has a pink, red, or brown color varying in intensity according to the length of the action. Sometimes a lavender shade is produced, and this is more apt to be the case when the silver chloride has been precipitated with excess of silver nitrate instead of excess of HCl.

Silver determinations of two specimens of the purified product were made, indicating the presence in one specimen of 1·77 per cent. of subchloride, in the other of 3·53.

By the continued action of heat for many hours a complete reduction to metallic silver takes place.

Photochloride obtained in this way has generally a brown or dull purple color. Boiled with nitric acid, it is apt to break up in as many minutes as some other forms would require hours for decomposition, yielding white chloride, while the nitric acid takes up small quantities of silver.

IDENTITY OF PHOTOSALTS WITH THE MATERIAL OF THE LATENT IMAGE.

It is proposed here to show:

1. That in the entire absence of light, sodium hypophosphite is able to effect a sensitive film of silver haloid exactly in the same way as does light, *producing a result equivalent to a latent image formed by light* and capable of development in the same way as an actual impression of light.

2. That these two effects, the impression produced by hypophosphite and that by light, comport themselves to reagents exactly the same way, and seem every way identical.

3. That the image produced by hypophosphite on silver chloride always gives rise to a positive development, but on silver bromide may give rise either to a direct or to a reverse image, *both of these effects corresponding exactly with those of light.* More than this, sodium hypophosphite may be made to reverse the image produced by light on silver bromide, and, conversely, light may be made to reverse the action of hypophosphite. So exact a correspondence in these remarkable properties can scarcely be fortuitous.

I.

A silver haloid formed in the absence of light and subjected to the action of sodium hypophosphite gives rise to the gradual formation of subsalt, which combines with the normal salt in the manner described in the previous part of this paper. This action of the hypophosphite closely corresponds with that of light. In its initial stages it is invisible, but can be brought out, in both cases by development.

If we form a film of chloride, bromide, or iodide of silver, and with a glass rod dipped in solution of hypophosphite make marks upon it, these marks can with the utmost ease be developed in precisely the same way as an image produced by exposure to light.

A very simple mode of operating consists in imbibing photographic paper with a solution of an alkaline haloid, drying, applying a silver solution, and then thoroughly washing, all of course with careful exclusion of active light. If the silver solution is acidulated with nitric acid, a drop to the ounce, the result is brighter, but this is not important. In any case the washing must be thorough.

Marks made on this paper can be developed with the oxalate developer with the utmost facility. If a strong solution of hypophosphite is applied cold, it may be washed off at the end of a minute, but a stronger impression is obtained by allowing it to wait a half an hour before developing. Or the action may be accelerated and increased in strength by laying the freshly marked paper on a hot surface, or, better, by steaming it, before applying the developer. A convenient mode of steaming is to lay two pieces of glass on a small water bath kept boiling, with a space between them. Over this space the paper is rested for two or three minutes. Paper prepared with a solution of KCl, KBr, or KI, dried, and floated on acidulated solution of silver nitrate and well washed, if marked with strong solution of hypophosphite and steamed for two or three minutes, will develop the marks as black as ink on a white ground. The use of heat simply gives a blacker development, but a very vigorous image may be got without.

(A similar result may be obtained by substituting for the hypophosphite a dilute solution of potash and an oxidable organic substance. With milk sugar the action is very energetic, and heat is quite superfluous.)

Both these are the initial steps of reactions which, when prolonged, result in the visible formation of the colored photosalts. It is a matter of interest that sodium hypophosphite, which produces the above described effects, has no developing power whatever.

II.

The two impressions, that formed by light and that by hypophosphite, are similarly affected by reagents.

As an example of this identity of effect produced on the two impressions, I first take the action of nitric acid.

Chloride, bromide, and iodide papers were exposed to moderate diffuse light under a screen with openings, for a proper time to form a latent image, the chloride and bromide for four or five seconds, the iodide for twenty or twenty-five. They were then cut into halves, and one half of each was soaked in strong nitric acid for five minutes. These halves were then washed for some hours, and were developed along with the halves not so treated. Result was latent image on silver chloride almost, if not quite, uninjured; on silver bromide, somewhat affected, but still strong; on silver iodide, entirely destroyed.

Similar portions of the same papers were then marked with hypophosphite and were cut into halves, and one half was subjected to the action of nitric acid in exactly the same way as the previous. The result was exactly as before. The hypophosphite marks on the half of the chloride paper that had been treated with acid came out in development as vigorously as on the half that had not been treated. The bromide paper showed the marks weakened by the acid, but still strong; on the iodide not a trace appeared. In all respects the result was the same. What the one resisted the other resisted, what destroyed the one destroyed the other.

Another confirmation is presented by the action of the alkaline haloids upon the latent image.

The latent images produced by light on chloride, bromide, and iodide of silver were all treated with cold and moderately strong solutions of potassic chloride, bromide, and iodide for half an hour, and were then subjected to development. It was found that all three silver salts bore the action of potassic chloride and bromide fairly well, the images were somewhat weakened, but strong developments were obtained without difficulty. But when potassic iodide was applied, the latent image was totally destroyed.

The visible effect of the alkaline haloids on the photosalts exactly corresponds with their action on the latent image. Potassic chloride and bromide, applied in moderately strong solution and cold have little effect, but potassic iodide quickly destroys them.

Therefore the action as well of nitric acid as of KCl, KBr, and KI is exactly the same on the latent image impressed by light on AgCl, AgBr, and AgI as it is on the corresponding photosalts.

III.

The impressions produced by alkaline hypophosphite upon silver chloride always give rise to direct images, darker than the ground on which they are formed. The same substance produces an impression on silver bromide which may by development produce either a direct or a reverse image. So that there is a perfect parallelism with the action of light.

The reverse action of light, sometimes called solarization, shows itself as follows. A film of bromide being exposed to light, part covered by an opaque screen, the exposed portion receives an impression capable of development, and this impression grows in strength to a certain point, then recedes and reaches a condition in which it is less susceptible of development than before exposure. All bromide films, even unexposed to light, will darken in a developing solution in time. The portion that under the action of light has reached the reverse stage resists the reducing action of the developer better than that which was not exposed at all, and consequently appears after development as light on a dark ground, and is therefore a reverse image. As to the cause of this action, we are as yet wholly in the dark. If the continued effect of light was simply to restore the affected part to its original state, we might attempt an explanation by affirming that the continued action of light undid its own work. But the fact of the resistance to reduction being greater than before exposure shows that some as yet unknown action of light is in play. The reverse action cannot be due to oxidation, as has been suggested, because hypophosphite reverses and certainly cannot oxidize.

The reversing action of light on silver bromide finds its counterpart in the action of sodium hypophosphite.

If we take bromide paper (it is immaterial whether in making it the bromide or the silver solution be applied first, but for these experiments on the reversal of the image it is essential that a pure neutral silver solution be employed and that after the second solution has been applied, the paper should be thoroughly washed, all the operations being of course performed by inactive light)—if we take such paper and make marks on it with a strong solution of hypophosphite, and then throw the paper into potassio-ferrous oxalate, we shall get a direct development; the marks will be stronger than the ground. If now we continually weaken the hypophosphite solution, we shall presently reach a point at which these marks are in development almost wholly indistinguishable from the ground on which they were made. But continuing the dilution still further, we presently reach a point at which the marks reappear, but this time reversely—as lighter marks on a darker ground. This result is obtained with about a two per cent. solution; the first mentioned effect comes with a solution of 25 or 30 per cent. So that according as we use the hypophosphite solution stronger or weaker, we obtain exactly opposite effects. Here the parallelism is striking but not perfect; at least it remains to be explained why the action in the two cases proceeds in a reverse order. All the other reactions show a perfect identity.

Time will also sometimes produce the same effect as dilution. Paper marked and put away for 24 or 48 hours, giving at first a direct image, may after that time give a reverse one. This effect is extremely uncertain and, I think, exceptional. I have kept very many pieces for periods from a few hours to several weeks, which first and last gave direct images only; a few became reversed. But the experiment itself, the opposite effect of strong and weak solutions, is liable to no such uncertainty.

Again, we make light and hypophosphite interact, and each reverse the other's action.

To make hypophosphite reverse the action of light, I take a piece of silver bromide paper, expose it to the action of diffuse daylight for a few seconds, then, taking it to the dark room, make marks upon it with a glass rod dipped in solution of hypophosphite. On developing with potassio-ferrous oxalate, the marks appear lighter than the ground. Or, what is perhaps more striking, we take two pieces of such paper, retain one in the dark room and expose the other from 5 to 20 seconds to diffuse light, then make marks on both with a glass rod dipped in strong solution of hypophosphite, and then, after allowing a few minutes for the hypophosphite to act, place them both in a solution of potassio-ferrous oxalate. The marks will develop, in the one case, as dark on a light ground, in the other (that exposed to daylight) as light on a dark ground.

We have here made the hypophosphite imitate the action of light; it has reversed the image in the same way as would result from a prolonged exposure to light. It will next be shown that light may be made to imitate the action of hypophosphite and reverse the effect already produced by that or other reducing agent.

If we take the red or purple silver bromide, preparing it with exclusion of light and the same precaution as in the case of a dry plate, and extend it over paper (it is best, though not essential, to mix it with a little gelatine to enable it to retain its hold on the paper in the subsequent treatment), dry it, and expose it to light under a screen such as a piece of opaque stiff pasteboard with openings cut in it, then apply potassio-ferrous oxalate, we shall obtain a very remarkable effect—all the parts exposed to light take a reversed development, and appear as lighter spaces on a dark ground. And this goes so far that we may expose till we get a visible and quite strong image, darker than the ground, and yet in development this darker portion will come out lighter than the ground. Indeed, I have one specimen which shows almost white figures on an intensely black ground. Before development these light figures were brown, by exposure to light, on a rose-purple ground. I have seen few more curious results than this.

From the foregoing it follows that red bromide, notwithstanding its intense coloration, is in the same condition respecting light as normal silver bromide that has received an impression of light so strong that any further influence of light would cause reverse action, only that a vastly larger proportion of its molecules are affected. In the case of the latent image formed by light on normal bromide, it would seem that the particles affected, although numerous enough to serve as a basis of development, are still too few and too scattered to be visible or affect the color. The photobromide on the contrary has its mass made up of them. Then, if exposed to light, the light carries them a stage farther—brings them to the reverse or "solarized" condition, and the parts affected by light develop less strongly than those not exposed.

So light can act the part of hypophosphite and hypophosphite that of light, interchangeably; each can produce a direct action, each a reverse, and each can reverse the other.

It then appears that in all the numerous ways in which it is possible to compare the photosalts with the material of the latent image, they are found to be identical. The proofs based on development generally, and especially on the reversal of the latent image, seem very strong, and these receive additional support from the exact identity of reactions shown by the photosalts and by the material of the latent image.

The question of the identity of the photosalts with the products of light on the silver haloids might perhaps be left with some confidence to the cumulative proofs here offered. But I hope to be prepared to give in the next number of this journal additional evidence from a new direction.

(To be continued.)

THE COSGROVE CONCENTRATED ROLLER MILL.

OUR milling friends will be aware that in many mills it is difficult to arrange for a system of gradual reduction, for want of sufficient floor room for the roller machines and scalpers. There are also many small mills in which a compact and partial system of reduction is indispensable. These cases are met by the Cosgrove concentrated roller mill, furnished with Stevens' rolls, which we illustrate in the annexed engraving. Fig. 1 of our engravings is a perspective view of the mill, Fig. 2 being a vertical section. This machine, which is manufactured by Messrs. W. R. Dell & Son, of 26 Mark Lane, London, occupies a floor space of about 25 square feet, or the same as one set of rollers, and is 24 feet high. It contains five sets

of corrugated iron rollers, arranged above each other in pairs. They are geared so as to run with a differential motion, one of each pair revolving at a speed of from two to two and a half times that of the other, which motion (the grooves in the rollers running lengthwise) cuts rather than crushes the grain, and thus makes the greatest amount of middlings, which is the much desired object. Under each set of rollers is a brush cylinder 3 ft. in diameter, which makes sixty revolutions per minute, running within a concave of wire cloth. These cylinders have eight brushes, each 3 in. in width, and between each pair of brushes are placed three fan blades, set at an angle of forty-five degrees, both the brushes and the fan blades running lengthwise of the cylinder.

The wheat is fed at the top of the machine, and passes the first set of rollers, which are only intended to break the kernels open and free the germ. It then falls to the brush cylinder, where the germ is brushed through the wire cloth, and the fine dirt from the crease of the grain sucked away by means of a suction fan fixed on the floor above. The cylinder also acts on the principle of a fan, and assists in making the separation. The broken wheat then falls to the second pair of rollers, where it is further reduced, and then to the second cylinder, where the middlings are brushed through the wire concave. The bran dust is sucked up into the dust room, the middlings falling to a conveyer below, while the coarser particles of wheat are brushed over one side of the concave, and drop to the next set of rollers for further reduction. This process of reduction and separation is repeated through the entire machine, and the wheat is all reduced to middlings, and the bran cleaned, when the product is elevated to the silk reels by one set of elevators. The plan of introducing a blast of air after each of the several reductions is an important feature. The air acts in this respect as a middlings purifier in removing the fine fluffy matter as fast as it is separated from the grain, and also in withdrawing the moisture and heat from the rolls. There is no fear of overloading the rolls in this system.—*Iron.*

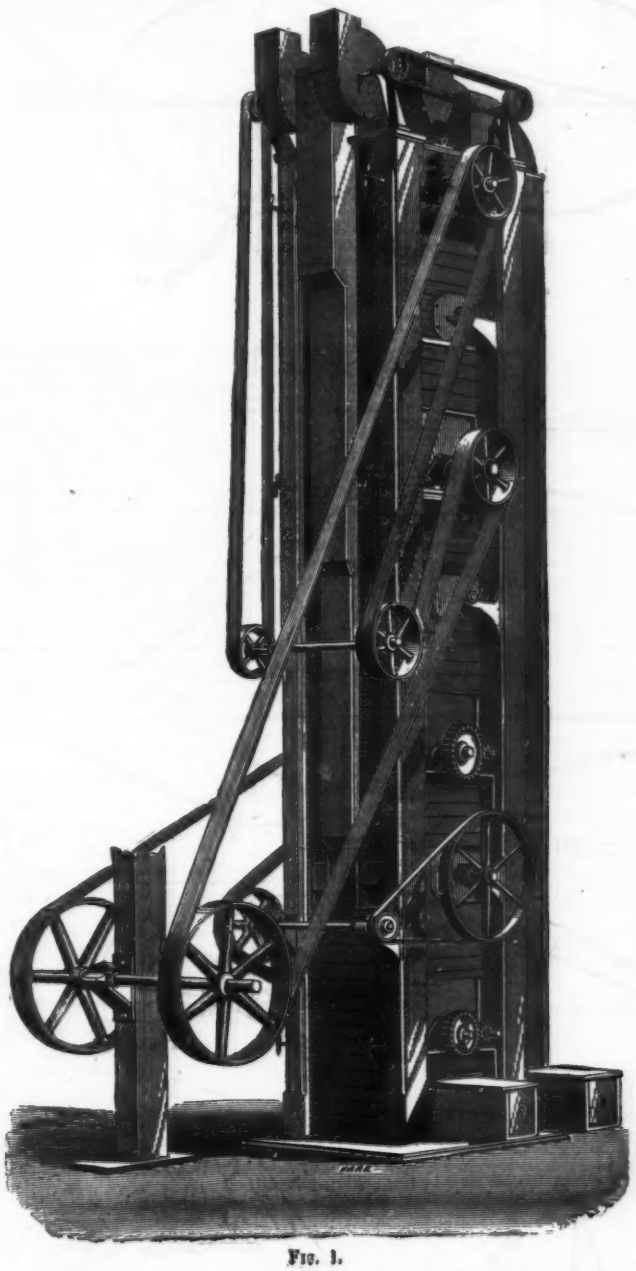


FIG. 1.

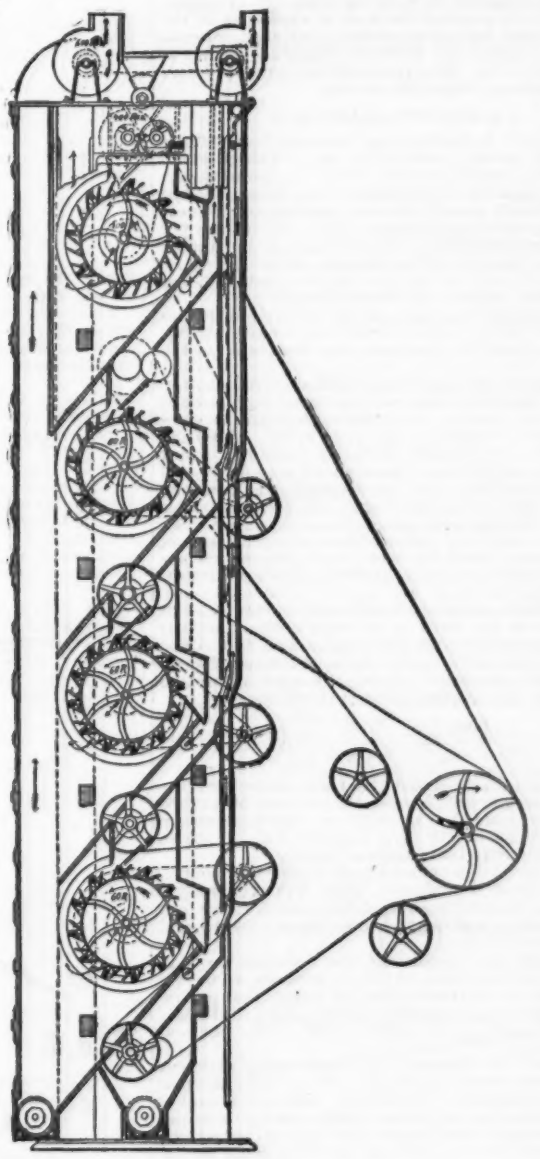


FIG. 2.

IMPROVED CONCENTRATED ROLLER MILL.

THE first public railway in England for passengers and freight was that connecting Liverpool and Manchester—a distance of thirty miles. This triumph of genius and perseverance over natural obstacles, the prejudices of self-interest and ignorance, was commenced October, 1826, and opened to the public July 30, 1829. A melancholy event, however, marred the proceedings. Mr. Huskisson, one of the king's ministers, was killed while alighting from the train.

THE USE OF EXHAUST STEAM FOR MANUFACTURING AND HEATING PURPOSES.

By CHAS. H. MANNING, Esq., Superintendent of the Amoskeag Manufacturing Company, Manchester, N. H.

THE use of exhaust steam for the purpose of heating work rooms dates back many years, where steam was used for motive power, but its use in many of the processes of textile manufactory has grown very much within the last decade, following closely on the extensive use of steam for motive power. There are many able mill managers who still doubt the wisdom and economy of such use of the steam, and these I shall endeavor to convince of the error of their way.

With a simple engine using high steam and short cut off, so as to expand nearly to the atmospheric pressure, it is more economical to run non-condensing than condensing, for with the non-condensing engine there will be a much smaller initial condensation in the cylinder, feed water of at least 100° higher temperature is available, and there is no expenditure of power to work an air pump. To this consideration may be added the saving of first cost of air pump and cost of repairs. As only about one-fourth of the exhaust steam can be used for feed water heating, it leaves the other three-fourths available for other purposes.

If we suppose an engine exhausting at the atmospheric pressure of 14·7 pounds per square inch, with a sensible steam temperature of 212° F., every pound weight of steam has, besides its sensible heat, 966·1 units of latent heat, which becomes sensible as the steam is condensed. In other words, every pound weight of exhaust steam at atmospheric pressure has 1,178 thermal units of heat in it, or can raise the temperature of 1,178 pounds of water from 39° to 40°, or through one degree of temperature; and the same is very closely true at any other temperature of feed water, the difference in specific heat at different temperatures being so small as to be neglected in all steam engine calculations without appreciable error.

Now, if the feed water is taken at 60° and is to be delivered at 200°, it must be raised 140°, and to do this we have 1,178—200=978 heat units available, and 978÷140 is very nearly 7; or, in other words, one-seventh the exhaust steam would heat all the feed water from 60° up to 200° and have as a surplus the one-seventh of the steam which was condensed. But as we do not get the full weight of water fed to the boiler from the engine again in the form of exhaust steam, it is well to allow from one-fifth to one-fourth the exhaust steam to heat the feed water, and this increased or decreased, according as the feed is received above or below the assumed temperature of 60°.

STEAM FOR HEATING.

Now, to use the remaining portion of the steam for heating purposes, it may be necessary to increase the back pressure on the engine to two pounds per square inch, at which pressure any building properly piped can be heated. To maintain the effective pressure on the piston when the back pressure is increased, it will be necessary either to increase the initial pressure or, better, to decrease the rate of expansion by following farther, and this increase will be the cost of heating.

If, now, the steam is exhausted at 17 pounds pressure absolute, that is, two and three-tenths above the atmosphere, we shall have 1,181 thermal units per pound weight. And considering that the water is trapped from the coils at two hundred degrees, we have 981 thermal units per pound available for heating. Now, if, instead of this, the heating is done with direct steam from the boiler at one hundred pounds pressure per gauge, or one hundred and fifteen absolute, we shall have, if we trap from coils at the same temperature as before, 1,217—200=1,017 thermal units per pound available for heating, or the relative values of the direct and exhaust steam for heating purposes are under the circumstances as 1,017 : 981, or as 1·036 : 1.

The sensible heat of the direct steam being 317° against 219°, the temperature of the exhaust, the former will do more heating in a given time with a given coil surface, but the radiating surface being properly proportioned, weight for weight, they are practically of equal value.

This statement is merely the reverse of the strongest argument for the use of high pressures for power purposes, for, as I stated in a previous paper, the great expenditure of heat in making steam is in changing the condition of the fluid from water to steam, after which a comparatively small expenditure of heat serves to increase the pressure, and the capacity for work increases with the pressure.

ECONOMY IN BACK PRESSURE STEAM.

In manufactories where large amounts of steam are required for dyeing, drying, and dressing material, and steam is used for power, it is evident that there is a large economy in using back pressure steam for all of these first named processes as well as for heating. If all these uses are not sufficient to consume all the exhaust say from a pair of engines, one cylinder may be used condensing or exhausting merely against the at-

mosphere, while the other exhausts against the necessary back pressure, which in any case will scarcely exceed ten pounds above the atmosphere. This need not affect the steady running of the engine in the slightest.

If the power is obtained from one cylinder, and only half the steam is required to do the work, if the valve chests are properly arranged, one end may exhaust against the back pressure and the other to the condenser or atmosphere as before, but, in this case, care must be exercised to divide the work equally between the two ends of the cylinder so as to maintain uniform rotation.

With equal cut-offs the cards taken from the end exhausting against the back pressure will, of course, least show the area and unbalanced pressure, and the first impression is that the cut-off must be lengthened at that end to equalize the work done on the two strokes; but a moment's thought will convince any one that this is a mistake, as the work done during any one stroke of a piston must be determined from the forward pressure urging the piston on one side and the back pressure resisting it simultaneously on the other side of the piston.

This being the case, steam must be cut off shorter on the end from which the exhaust is used, and followed further on the other end. Where a compound engine is in use, the steam may be used from the receiver, the high pressure cut-off being lengthened sufficiently to allow the equalization of work between the cylinders. This amounts to utilizing the work of expansion of the steam to be used for manufacturing purposes between the limits of initial and receiver pressures, instead of losing most of it by free expansion through a pressure regulating valve or other like device.

A DEFINITE EXAMPLE.

It may be well to illustrate my meaning by a definite example. So we will consider the case of a single cylinder condensing engine of six ft. stroke of piston, thirty-six inches diameter of cylinder, using steam of one hundred pounds gauge pressure, cutting off at one-eighth of the stroke and making sixty revolutions per minute. There is sufficient work to use all the exhaust steam at a pressure of ten pounds above the atmosphere and we wish to find the relative costs of doing this work with exhaust and direct steam.

If the condenser maintains about twenty-four inches of vacuum in the cylinder, during the exhaust stroke, the mean unbalanced pressure may be found as follows:

As the number of times steam expanded (N) is to the hyperbolic logerith of that number (Log$_e$. N) plus one; so is the initial pressure (absolute) to the mean forward pressure; or 8 : 2·07944+1 : : 100+15 ; 44·267. The back pressure with twenty-four inches of vacuum is about three pounds, so the mean unbalanced pressure would be 44·267—3=41·267. Now, to maintain the power of the engine against a back pressure of twenty-five pounds, or ten above the atmosphere, the steam must follow further, and this increased consumption of steam, less the decreased cost, by reason of higher feed water temperature, will be the cost of doing the work with exhaust steam.

It is, therefore, necessary first to find the new point of cut-off; and as the work to be done is the same, the mean unbalanced pressure is the same, and this added to the back pressure will give the mean forward pressure, or 41·267+25=66·267. Using the same proportion as before, we have N . Log$_e$.N+1 : : 115 : 66·267, or

$$\frac{\text{Log}_e.N+1}{N}=\frac{66{\cdot}267}{115}=0{\cdot}5761.$$

This must be solved by "trial and error," and we find N=4·2 very nearly, or steam is to be cut off at 0·238 of the stroke instead of $\frac{1}{8}$=0·125, as before, or we are using 0·238—0·125=0·113 of a cylinder full of steam more at each stroke than we were before.

The volume of the cylinder is 42·4 cubic feet nearly, and 42·4×0·113=4·79 cubic feet. This 4·79 cubic feet of steam at one hundred pounds gauge pressure from feed water at one hundred degrees costs about 1,269 thermal units.

Under these last conditions, the terminal pressure will be 27·3 lb. absolute, at which pressure we have a cylinder full, or 42·2 cubic feet of steam, and this represents 2,610 thermal units available above feed water at 100°, or a net gain of 2,610 — 1,269 = 1,341 thermal units per stroke.

Boilers with an efficiency of 0·8 are doing excellent duty. So this would represent $\frac{1341}{0{\cdot}8}$ = 1676 thermal units of fuel supplied to the boilers; and as a pound of anthracite coal gives off about 14,000 thermal units per pound, this would equal about 12 lb. of coal per stroke, or about 864 lb. of coal per hour saved by using the exhaust steam.

The foregoing calculations are not intended to be exact, as no account has been taken of the effect of clearance, and the back pressure assumed is an extreme case; and where less back pressure is required, the results are even better than above.

AN ACTUAL CASE.

As an illustration of the actual facts of the case, I will cite a pair of Corliss engines similar to the single cylinder on which these figures are based.

These engines are used to supplement water power in gingham mills using at all times a very large amount of steam for dyeing and drying purposes. These engines can be started and run at any time up to 1,000 horse power, without saying a word about it in the boiler house, simply by diverting the steam through the engine. At the end of the day, the coal account will show an increase of from three to five tons.

In winter time, when a large amount of steam is used for heating the mills, still greater power can be developed at the same rate of cost, but in summer a portion of the exhaust escapes.

Under the latter circumstances, it is best to carry the steam pressure to its highest initial point. But in winter it is sometimes necessary to lower the steam pressure so as to cause the engines to follow further and deliver a greater weight of steam per stroke, and this is also necessary when but a limited amount of power is required. Where one end only of the cylinder is used against back pressure, if the fly wheel of the engine is heavy enough to maintain steady speed with unequal work done in the two ends of the cylinder, the steam can be divided between the two ends so as to vary the amount of exhaust steam available between considerable limits, and keep the power constant. Where the use for such steam is very limited, it is undoubtedly more economical to use direct steam than to run the engine against a considerable back pressure and then waste the larger part of it.

Every case, however, is capable of solution by the foregoing principles, and any engineer should be able to tell at just what point in a particular case it ceases to be profitable to use back pressure steam.—*Textile Record.*

[Continued from Supplement, No. 614, page 9804.]

SIMULTANEOUS DEAD POINTS.

By Prof. C. W. MacCord, Sc.D.

II.

The general arrangement of the combination shown in Fig. 7 is identical with that of Figs. 2 and 6 in the preceding article. But its action differs from that of the latter diagram, in the respect that the rotations of the levers are in opposite, instead of in like, directions; and as might be expected, if the relative dimensions of the parts be the same, the velocity ratio will also be different in these two cases. In order to determine that ratio, it was necessary to locate the instantaneous axis, by the solution of an imperfect quadratic equation, the result being, as deduced from Fig. 6,

$$x-\frac{r\,l}{\text{R}-r}=\frac{\sqrt{\text{R}\,l\,r(\text{R}+l-r)}}{\text{R}-r};$$

and in that diagram the position H of the instantaneous axis was fixed by taking the positive value of the second member of this expression, whence in that case the velocity ratio was found to be

$$\frac{v}{v'}=\frac{\text{R}\,l\,r+r\sqrt{\text{R}\,l\,r(\text{R}+l-r)}}{\text{R}\,l\,r+\text{R}\sqrt{\text{R}\,l\,r(\text{R}+l-r)}}$$

Now the negative value may be used instead, which gives for Fig. 7, as the magnitude of A H,

$$x=\frac{r\,l-\sqrt{\text{R}\,l\,r(\text{R}+l-r)}}{\text{R}-r}$$

We had for the velocity ratio

$$\frac{v}{v'}=\frac{x+l}{x}\times\frac{r}{\text{R}}$$

and with the new value of x this gives

$$\frac{v}{v'}=\frac{\text{R}\,l\,r-r\sqrt{\text{R}\,l\,r(\text{R}+l-r)}}{\text{R}\,l\,r-\text{R}\sqrt{\text{R}\,l\,r(\text{R}+l-r)}}$$

The velocity ratio then is not indeterminate, but may have either of *two* values only, according to which root of the quadratic is selected; but in this instance the directional relation is also determined by that selection, and, *vice versa*, the assumption of the relative directions fixes the relative velocities of the motions.

Let us now suppose the two levers to be of the same length, less than that of the link; that is, let R = r; then the expression reduces to

$$\frac{v}{v'}=\frac{0}{0}$$

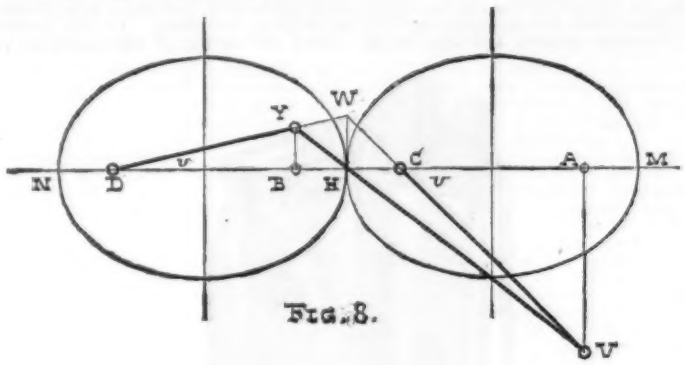


Fig. 8.

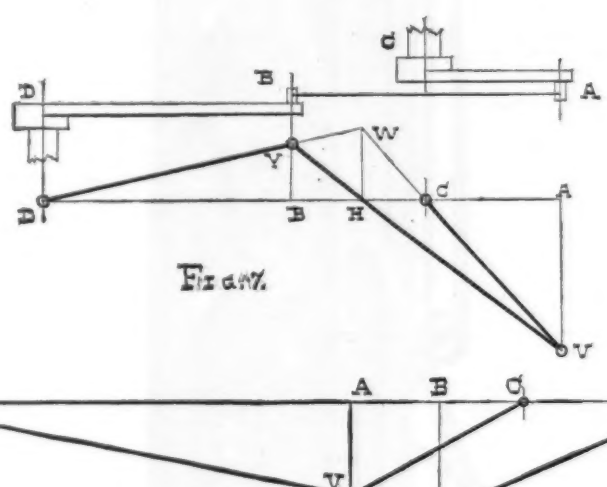


Fig. 9.

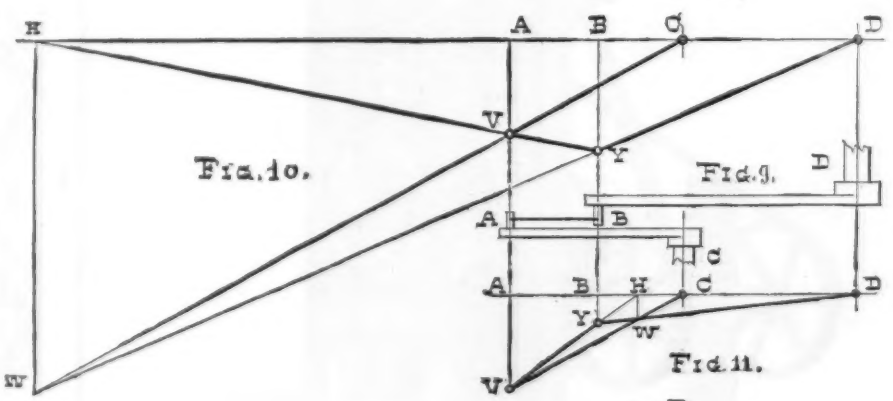


Fig. 10.

Fig. 11.

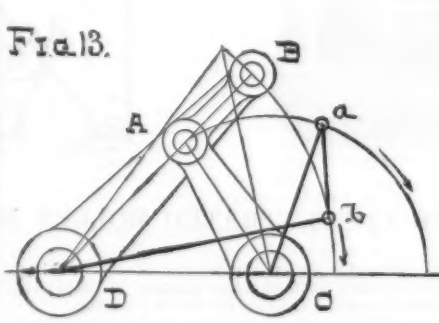


Fig. 13.

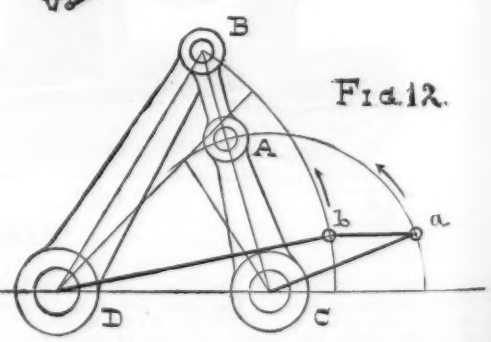


Fig. 12.

which is clearly absurd, since the combination is then equivalent to the link joining the free foci of a pair of elliptical wheels, whose velocity ratio is certainly not indeterminate. In order to get at the true result, the supposed equality should be introduced at the outset. We have here, as before,

$$\frac{\text{H A}}{\text{H B}}=\frac{\text{H D}}{\text{H C}}\times\frac{\text{A C}}{\text{B D}}=\frac{\text{H D}}{\text{H C}}\times\frac{r}{\text{R}}$$

that is, when R = r,

$$\frac{\text{H A}}{\text{H B}}=\frac{\text{H D}}{\text{D C}}$$

and our original equation becomes

$$\frac{x}{x+l}=\frac{x+l+r}{x+r};$$

whence in this case we find

$$x=-\frac{l+r}{2}$$

And for the velocity ratio, we have

$$\frac{v}{v'} = \frac{H C}{H D} = \frac{H B}{H A} = \frac{x+l}{x}$$

and with the new value of x this becomes

$$\frac{v}{v'} = \frac{l - \frac{l+r}{2}}{\frac{-l+r}{2}} = -\frac{l-r}{l+r}$$

Now this result agrees precisely with that reached in the case of the elliptical wheels above referred to, at the instant when the major axes coincide with the line of centers, as illustrated in Fig. 8, where the pitch ellipses are represented, centered on the fixed foci, C, D. The free foci are A and B, so that A C, B D are

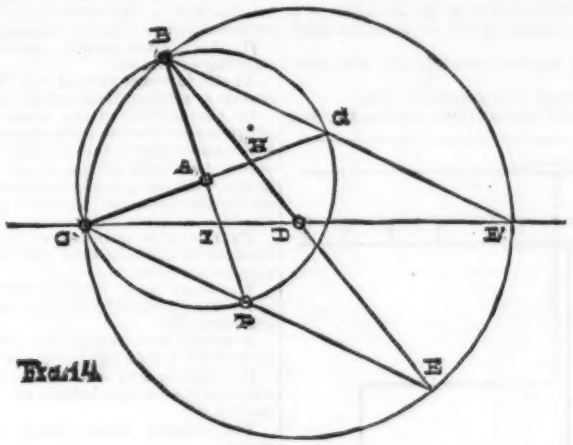


FIG. 14.

in effect two equal levers, which may be connected by a link, A B, equal in length to C D, thus representing the system at the instant of collapse. And the value of H A, as above found from the formula, locates the instantaneous axis at H, the point of contact of the ellipses, as it obviously ought to do.

It does not, however, necessarily follow that if the positive root be used in one case and the negative root in another, the rotations will have opposite directions. This occurs, as we have seen, when the link is longer than the short lever, and also when the levers are equal, if the link be of greater length. Now in Fig. 9 the link is shorter than either of the unequal levers. If we use the positive root, the instantaneous axis, H, falls to the left of A, as in the diagram, Fig. 10; if we use the negative root, H will fall to the right of B, as in Fig. 11. In either case, then, both A and B must move in the same direction, and consequently, since both levers lie on the same side of their respective centers, they will turn in the same direction.

In Fig. 10 we have, for the proportions

$$R = I,\ l = 3,\ r = 6,$$

the value $$A H = 16{\cdot}39,$$

and $$\frac{\text{ang. vel. about D}}{\text{ang. vel. about C}} = \frac{100}{127} \text{ nearly;}$$

in Fig. 11 we have $A H = 4{\cdot}39$,

and

$$\frac{\text{ang. vel. about D}}{\text{ang. vel. about C}} = \frac{100}{433} \text{ nearly.}$$

of the shorter lever, which must now also retrograde, and the remainder of the action will be as in Fig. 11. Thus neither lever can make a complete rotation, the movement consisting of alternate reciprocations, the law of variation in the velocity ratio during the forward travel of either lever being different from that which obtains during the backward travel.

We may make $R = r$ in this case also, but if we do, although the negative root will determine a position of the instantaneous axis to the right of B, as above shown, yet there cannot be any actual rotation of the levers in opposite directions; for the inward dead point for B D, which determines the limit of that lever's swing to the right, occurs at the very instant of collapse, when both levers are horizontal and pointing to the left; and the outward dead point for A C, corresponding to the position in Fig. 12, could only occur when both levers should point to the left, which would require B D to move to the right, through an arc of 180°. On the other hand, the use of the positive root removes the instantaneous axis to an infinite distance toward the left, leaving the levers free to rotate continuously in the same direction with equal angular velocities.

Thus far, the two levers at the instant of collapse have been considered as lying in the same direction. But the two dead points may occur simultaneously when the levers lie in opposite directions. Taking for the first illustration the same proportions as in Fig. 4, it will be seen that supposing C A in Fig. 14 to turn to the right, after passing the single dead point position shown in Fig. 1, a further movement will cause B D to return, as here indicated by the arrows, and that when C A becomes horizontal the system will again collapse, B coinciding with C, and each lever having an inward dead point.

The construction is identical with that of Fig. 4, and it is at once apparent that since the triangles I C P, H B G, are similar and equal, the instantaneous axis, H, will at the time of collapse coincide with I, the intersection of the line of the link with the line of centers. And the location of that point at that time may be found precisely as in Fig. 4, thus:

we have $$I P : I B :: P C : B E',$$

whence $$I P : P B :: P C :: P C + B E',$$

and at the limit this gives

$$I P : 2r :: 2r : 2R + 2r$$

or $$I P = \frac{2r^2}{R+r}$$

Then $$\frac{v}{v'} = \frac{C I}{D I};$$

but $$C I = 2r - I P = 2r - \frac{2r^2}{R+r} = \frac{2Rr}{R+r}$$

and $$D I = R - C I = R - \frac{2Rr}{R+r} = \frac{R(R-r)}{R+r}$$

whence $$\frac{v}{v'} = \frac{2Rr}{R(R-r)} = \frac{2r}{R-r}$$

The same result may also be reached by the mode of reasoning adopted in connection with Fig. 5; the form of the diagram is shown in Fig. 15, and the details of the analysis are so similar to those of the case alluded to, that they need not here be given.

In this case, also, the geometrical deduction is impossible unless the link be equal in length to one of the levers; if this be not so, we must, as the first step toward ascertaining the velocity ratio, determine the position of the instantaneous axis by the algebraic process.

Thus in Fig. 16, if as before we let

$$A C = r,\ A B = l,\ B D = R,\ A H = x,$$

we shall have

$$H C = x + r,\ H B = x + l,\ H D = R - l - x.$$

Here again $$\frac{H A}{H B} = \frac{H D}{H C} \times \frac{A C}{B D};$$

or $$\frac{x}{x+l} = \frac{R-l-x}{x+r} \times \frac{r}{R}$$

whence $$x = \frac{\sqrt{R\,l\,r\,(R-l+r)} - r\,l}{R+r}$$

Then to find the velocity ratio, we have as before

$$v = \frac{B Y}{R},\ v' = \frac{A V}{r};\ \therefore \frac{v}{v'} = \frac{B Y}{A V} \times \frac{r}{R'} = \frac{H B}{H A} \times \frac{r}{R}$$

in which $$H A = x, \text{ and } H B = x + l,$$

whence $$\frac{v}{v'} = \frac{x+l}{x} \times \frac{r}{R};$$

which becomes, by introducing the value of x just found, and reducing,

$$\frac{v}{v'} = \frac{r\sqrt{R\,l\,r\,(R-l+r)} + R\,l\,r}{R\sqrt{R\,l\,r\,(R-l+r)} - R\,l\,r}$$

If in this expression we make $l = r$, it reduces to the form $\frac{v}{v'} = \frac{2r}{R-r}$, the correct value of the velocity ratio in Fig. 15, as previously deduced.

Now, it will be apparent at a glance that with two levers and a link, of given lengths, the greatest possible distance between the centers will be the sum of the three, as in Fig. 17, where

$$C D = R + l + r.$$

And it is equally obvious that in this case, which involves two simultaneous *outward* dead points, the system, whatever the relative lengths of the three elements, is equivalent to one rigid bar fixed at the ends, and incapable of motion.

On the other hand, the least distance between the fixed centers which will permit two dead points to occur at the same instant will be such that, as in the cases now under consideration, the two levers may be folded upon the link.

Prof. Willis illustrates this by a diagram, the proportions of which we reproduce in Fig. 18, and in reference to it he says ("Principles of Mechanism," p. 213): "And this system is similarly immovable, having two inward dead points."

In the special case he has chosen, this is undeniably true; but the only possible inference from his words is that the system is immovable by reason of the simultaneous existence of the similar dead points, and always will be when that condition occurs, whatever the proportions.

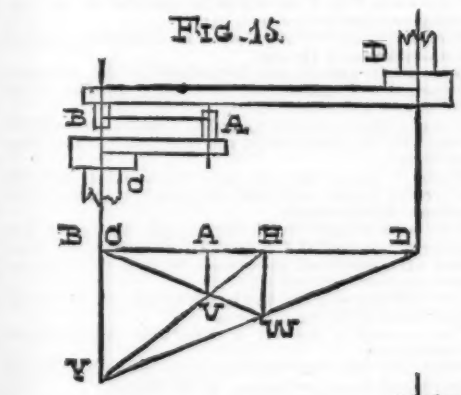


FIG. 15.

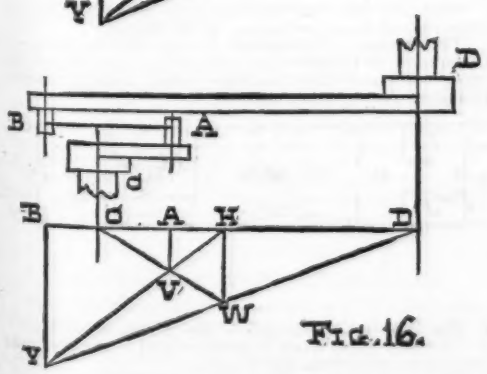


FIG. 16.

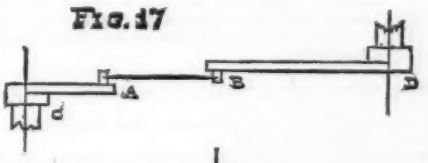


FIG. 17.

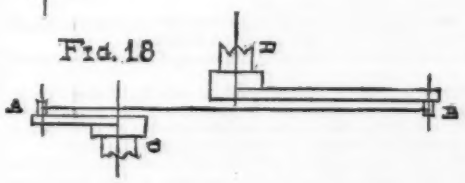


FIG. 18.

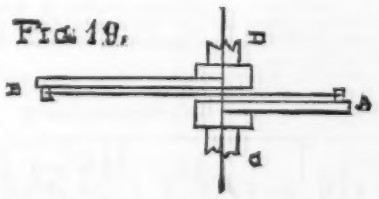


FIG. 19.

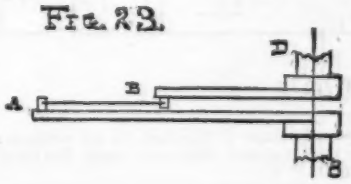


FIG. 23.

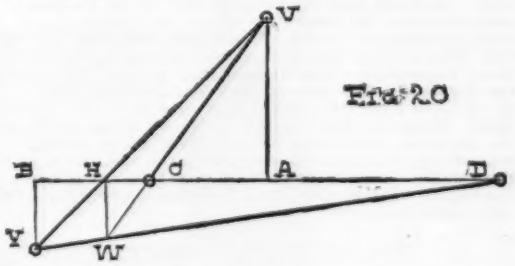


FIG. 20.

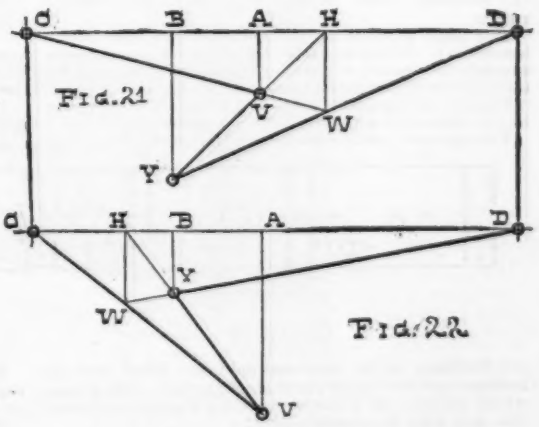


FIG. 21.

FIG. 22.

The two succeeding diagrams farther illustrate the movements of the system thus proportioned. Starting from the horizontal position, the levers move as in Fig. 10, and continue thus to turn in the same direction until C A reaches an outward dead point, as shown in Fig. 12. B D having now reached the limit of its excursion must begin to return, but C A may still advance until, as in Fig. 13, B D reaches an inward dead point. This fixes the limit of the forward swing

This, however, as we have seen, is an error. The motion of the link at the instant of passing the line of centers, whenever the system is such that it can pass it at all, is one of rotation about some point of that line. And the location of that point depending in general upon the solution of an imperfect quadratic, it follows that there are two points which will satisfy the condition, if the equation have two real roots. But let the proportions be such as to render one or both these

roots imaginary; there would be only one such point in the former case, and in the latter none at all.

Now, if in the expression

$$x = \frac{\pm\sqrt{R\,l\,r\,(R-l+r)} - r\,l}{R+r}$$

we make $l = R + r$, it reduces to

$$x = \frac{-r\,l}{R+r} = \frac{-r\,(R+r)}{R+r} = -r$$

and the combination assumes the form shown in Fig. 19; the fixed axes C and D coincide, and the link and levers can move only by revolving as though forming but one piece, which in effect they are. This, then, is the limit, by exceeding which the system becomes immovable, as in Fig. 18, where l is greater than $R + r$, a supposition which renders the value of x imaginary in the above expression.

If we make l = zero, we have $x = \infty$; not a practical supposition in link work, but answering to the conceivable case in which the two crank pins should be replaced by two knife edges in contact on the line of centers, which would act upon each other only for the instant, their motions being necessarily perpendicular to the line of centers.

But the link may have any length between these limits, $l = 0$ and $l = R + r$, without rendering the combination theoretically rigid, though it may be conceded that practically its applications will not be numerous.

Referring again to Fig. 16, it is to be noted that the rotations are in opposite directions, since H falls to the right of A; the same would also be the case were H to lie at the left of B. In Fig. 20, however, using the negative root, the instantaneous axis falls between A and B. Those two points then must move in opposite directions, causing the two levers to turn the same way, as shown by the arrows. In the combinations of Figs. 16 and 20, the shorter lever, far from being immovable, is capable of continuous rotation; but with the proportions given in Figs. 21 and 22, the motion of the system is restricted to limited vibrations of the two levers, the case being analogous to the one illustrated in Figs. 9 to 13 inclusive.

In like manner we shall find that there is a limit, by transcending which the system first investigated, involving one outward and one inward dead point simultaneously occurring, will become immovable. The instantaneous axis was in that system located by the formula

$$x = \frac{r\,l \pm \sqrt{R\,l\,r\,(R+l-r)}}{R-r};$$

in this let us make $r = R + l$; in consequence we have

$$x = \frac{r\,l}{R-r} = \frac{r\,l}{R-R-l} = -r$$

and the system assumes the form shown in Fig. 23, where C and D coincide, and the combination as in Fig. 19 can merely rotate as if forming a single piece.

If r be made greater than $R + l$, the effect is to move C farther to the right, and the quantity under the radical being negative, both values of x become imaginary. That is to say, there is no point about which the link can rotate, and the mechanism is immovable.

It may be noted that if in this last formula the sign of r be changed, we have two outward dead points, as in Fig. 17, the expression becoming then

$$x = \frac{-r\,l \pm \sqrt{-R\,l\,r\,(R+l+r)}}{R+r}$$

in which again the quantity under the radical is negative and both roots imaginary, thus proving the system to be rigid, as stated by Prof. Willis.

But if there be, at the same instant, either two inward dead points or one inward and one outward, the system is movable within the limits of proportion above deduced, and the velocity ratio is in no case indeterminate, but must have one of two definite and easily ascertained values. It may be very true that this circumstance has, in practical arrangements, no great importance; nevertheless, it is as well that, in the discussion of the theory, all the deductions should be in accordance with each other and with physical facts. Moreover, while in the majority of cases the simultaneous occurrence of two dead points may be undesirable, it is quite easy to see that there may be a respectable minority in which it would not be fatal to the objects in view, and such combinations might serve very useful purposes.

THE PRESIDENT'S TRAIN.

A SHORT description of the presidential train now with Mr. Cleveland in the West may be of interest to the readers of the SCIENTIFIC AMERICAN SUPPLEMENT.

The train is made up of three vestibule cars and a locomotive. The first car is what is known as a composite car, the second is a common vestibule car, and the third is the President's private car.

The cars are connected by the vestibules, which practically make the whole train into a single car.

The cars are painted on the outside with the standard Pullman colors, olive and gold, are fitted with air brakes, and the best style of steel springs, with a tank which supplies all water required for washing purposes, etc., and with the electric light.

The trucks are of the No. 5 type, with three 42 inch paper wheels.

If the reader will accompany me on the diagram (Fig. 1), we will walk through the train, throwing a casual glance on everything of interest on our way.

We will start at the forward part of the composite car, the Alfarata, in the baggage room, A.

We notice on all sides the baggage of the passengers. Electric lights dissipate the gloom of the rear part of the compartment and enable us to see in a pen by itself the dynamo on one side of us, and the refrigerator, not shown on the diagram, on the other.

On the side of the car we notice the ammeter and cut out switch, and on the back of the room the resistance box and regulating switches of the dynamo and lamp circuits.

We shall come back and interview the dynamo and switch more closely. So we pass on by a pump to be used in case of fire, on one side, and the wine closet on the other. We try the door of the latter and find it locked.

Opening the door in front of us, we see a common sleeping car section with four berths.

A two lamp electric light fixture ornaments the ceiling. This section is to be occupied by the *attaches* of the train.

From this we step into the next room, B, the smoking room.

At the rear, and directly facing us as we enter, is a handsome mirror, with a mantelpiece over and on each side of it.

On the mantelpieces repose Oriental jars and hookahs.

Under these pieces stands a comfortable sofa.

The chairs are large and comfortable, with spreading

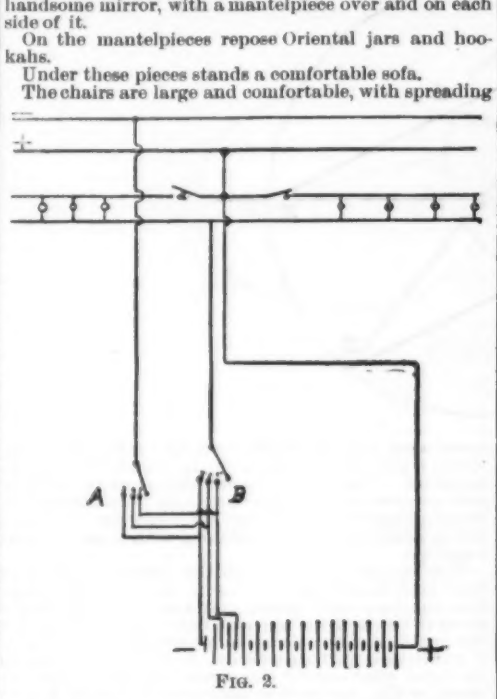


FIG. 2.

legs, and can be moved from one place to another anywhere in the car.

They and the sofa are upholstered with a rich golden brown, highly suggestive of cut cavendish.

The windows are curtained with the same material, and the woodwork is of oak and bird ash, highly polished.

The floor is covered with a thick carpet, of a design and color in keeping with the hangings and finishing of the room.

At each side of us as we stand in the front of the room is a writing desk and a book case filled with works of the standard authors.

An electric lamp with flexible cord attachment furnishes light to the reader or writer, and several electric fixtures hang from the ceiling of the car.

We leave this room, and as we pass the barber's shop, C, we take a hasty look at it.

A real barber's chair has the lion's share of the room, but on our left the apparatus for shampooing has just managed to shave in, while on our right stands a good sized bath tub.

The labors of the tonsorial artist are lightened by a two lamp fixture and a lamp with a flexible cord connection.

We turn away and leave the car, the heater to our left, the saloon to our right.

As we pass through the vestibule we notice the single electric light in the gilded dome overhead.

We now throw aside our cigars and enter the second car, the Velasco.

On our left is the heater and on our right are two saloons. The passageway is illumined by an electric light, which enables us to see the handle of the door of the section, D, which we turn and open the door.

There is nothing here of interest, so we shut the door again and walk through the passage to the middle of the car, F, passing on our way the buffet, E, where is kept the silver, glass, etc., of the car, and the closet on the right, where are the controlling switches, C, for the lights of this car.

The sections in F are upholstered in blue, and the sides of the car are finished in dark woods.

In these sections repose the presidential party.

We walk hurriedly from F through G, an ordinary section, and see nothing new until we reach the third and last car, the P. P. C.

We notice at first that, instead of one door in the middle, there is a door at each side.

The right hand one opens into the kitchen, H, where there is a sink, a table, and a range, not a commonplace gas stove, but a *bona fide* range, from which untold wealth of good things will make their appearance during the next thirty days.

Communications between the pantry and kitchen are carried on by means of a small slide.

We walk through the doorway from the kitchen to the passageway, past the pantry, I, past the saloon, J, where stand the switchboards that control the light of the P. P. C., into the great room of the train, K, the most elegant and withal the most homelike.

This is the living room of the President and his wife. As we enter we pass a section with four berths, which, during the day, is part of the large room, but when the shades of night fall, presto! fall the section shades, and it is a room by itself.

The number of lamp fixtures and the size of the windows are the most noticeable things in this room.

Instead of two lamps to a fixture, in the presidential car there are four, which are inclined to the vertical, flaring from a common center.

This gives a very graceful effect.

The lamps are controlled by three sets of switches: First, the main switches in the saloon, J, which control the whole car; second, switches at convenient places on the side of the car for each fixture; and third, the switches in the fixtures themselves for each lamp.

By this means perfect control is obtained over the lighting of the car.

At the forward part of the room where we stand also stands a writing desk and an organ.

In the middle of the room is a center table which supports an electric lamp stand beautifully worked in brass and copper, and beyond it a large sofa stretches across the back of the room. On each side electric lamps with cut glass globes cast their lights before us, while the immense windows give a wonderful air of freedom to the whole room.

This room is upholstered in wine-colored silk plush, finished in oak and bird ash, and carpeted with a design in old gold.

We must leave this delightful room, and we now enter the President's private apartment, M, and dressing room, N.

A spring bed graces the first apartment, which is lighted by a four light electrolier and two single lamps.

By turning a switch, another lamp is put in series with the two single lamps, and a soft night light is obtained.

The dressing room boasts a mirror and a spacious closet.

On each side of the mirror is an electric lamp shaded by a red, white, and blue shade, for electricity is nothing if not patriotic.

Leaving these apartments, we enter the observation room, O.

This room is finished in mahogany and upholstered with blue *glace* plush.

The two sides and the back of the room are nothing but windows, through which one has an uninterrupted view of the country.

A sofa similar to the one in the large apartment runs across the front of the room, where one may recline in comfort and gaze at the scenery as it scurries away to the rear.

From this room we step on to the back platform, which has no vestibule, and from there to the ground.

And now that we have traversed the whole train, we will look more closely into the details of the electric lighting.

In Fig. 1 the positions of the electric lamps are shown by the symbols, o = single lamp; o—o = two lamp fixture; | | = four lamp fixture.

The lamps are lighted by the current from a battery of accumulators (*b*) charged by the current from a dynamo (*a*) in the composite car Alfarata, which receives its power from the axle of the car wheel.

A dynamo and vertical engine were put into the baggage room to charge the accumulators, but at the last moment it was decided to take the power from the axle.

The positions of the dynamo (*a*) and accumulator (*b*) are shown in Fig. 1, as well as the position of the controlling switches (*c*) for each car.

The accumulators are placed in dust-proof wooden boxes underneath the car.

The accumulators are furnished by the Electrical Accumulator Company, of New York, and are of the type known as the 23 C cell.

Four of these cells are placed in a crate, connected in series, with flexible cord at the free positive and negative poles.

Eight of these crates are used for lighting each car, the crates being connected in series by means of the aforesaid flexible cords.

The total weight of the battery per car is less than fourteen hundred (1,400) pounds, and the total space taken up is less than that taken up by a cube two and three-quarter feet on a side.

The battery will run the lights of the car for about eight hours with one charging.

The wiring of the car is done with No. 4 okonite covered cable.

With this wire less than one-quarter of a volt drop is experienced from the battery to the lamps.

The dynamo is furnished by the Electro-Dynamic Company, of Philadelphia, and gives one hundred and fifty volts and forty amperes when making twelve hundred revolutions a minute.

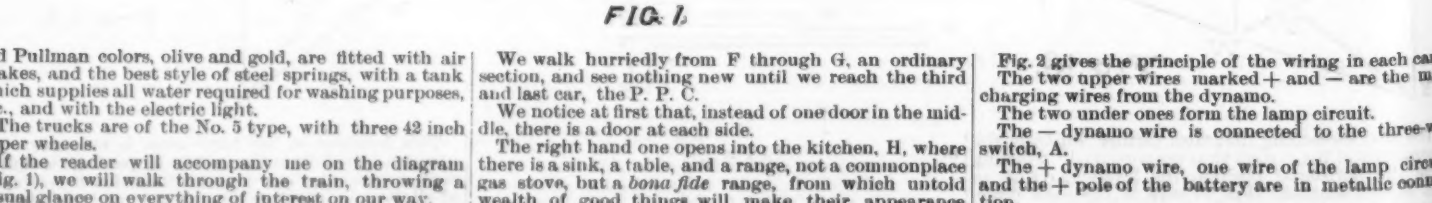


FIG. 1.

Fig. 2 gives the principle of the wiring in each car.

The two upper wires marked + and − are the main charging wires from the dynamo.

The two under ones form the lamp circuit.

The − dynamo wire is connected to the three-way switch, A.

The + dynamo wire, one wire of the lamp circuit, and the + pole of the battery are in metallic connection.

On each side of the connection of the lamp circuit is a switch which, when open, cuts connection with the lamp circuit.

The other wire of the lamp circuit goes to the three-way switch, B.

The — poles of the first three cells of the battery are connected to 1', 2', 3' of the lamp circuit switch, and 1, 2, 3 of the charging switch.

By means of this arrangement, any of the following results may be obtained:

(1st.) Dynamo switch closed on 1. Lamp circuit switches open. Dynamo running. Result: We charge battery of 30 cells from dynamo.

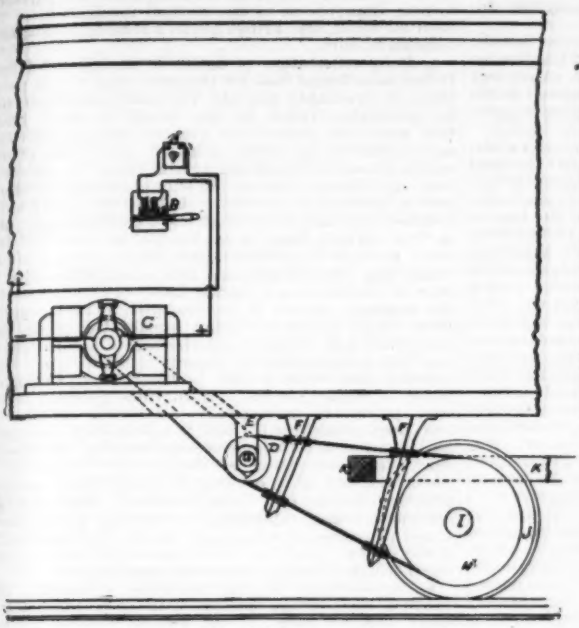


FIG. 3.

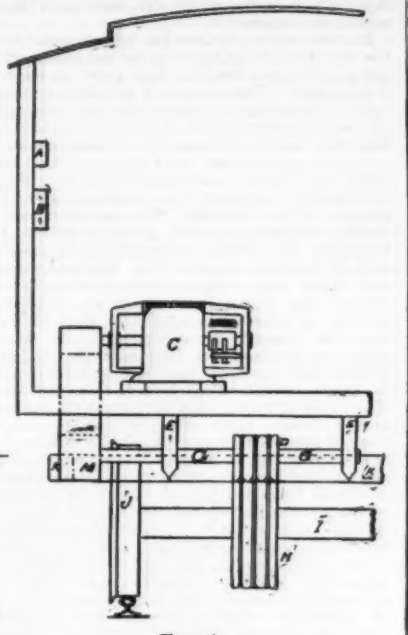


FIG. 4.

(2d.) Same, but dynamo not running. Result: Battery connected to the main charging circuit from where a current may be taken to light another car.

(3d.) Dynamo switch open. Lamp switch closed on 1. Lamp switches 1 and 2 closed. Result: Battery lights the lamps.

(4th.) Both dynamo and lamp switches closed. Result: Dynamo lights lamps and charges battery at the same time.

These combinations are possible with thirty-one and thirty-two cells also, as can readily be seen from the diagram.

When both the switches, *a* and *b*, are closed, all the lamps may be lighted.

When one is closed, only the lamps on that circuit may be lighted.

When both are open, no lamps may be lighted.

Fig. 3 and Fig. 4 show the method used to transmit the power of the rotating axle to the dynamo shaft.

Fig. 3 is a side view, and Fig. 4 an end view, looking forward.

On the axle is keyed the grooved pulley, H.

On the countershaft, G, running in bearings in the iron hangers, E E, is keyed the grooved pulley, I.

Three coiled steel wire belts run from the grooved pulley, H, to the grooved pulley, I.

These belts run between two sets of slotted pulleys held in the iron hangers, F F, shown in Fig. 3.

These hangers have been omitted in Fig. 4 to avoid confusion.

By this means all tendency of the belts to interwind is avoided.

To the outer end of the shaft, G, a brass pulley, M, is keyed, from which a leather belt runs through two slots in the floor of the car over the pulley of the dynamo, C.

When the train is traveling at the rate of forty miles an hour, the armature makes about thirteen hundred revolutions a minute.

At B the cut-out switch is placed, with ammeter at A.

The construction of the cut-out switch is very simple.

It consists of two electro-magnets traversed by the full current when the switch is closed.

The circuit is made through the armature by pressing it up against the electro-magnet, when it makes contact with two pieces of spring brass, so arranged that they always tend to push the armature away.

The armature arm is pivoted at one end.

The weight of the armature and arm and the effect of the springs all tend to make the armature drop and thus break the circuit.

A small spring connected to the handle of the armature allows an adjustment of the switch so that it may cut out at different strengths of current.

When the current diminishes, the attraction of the armature to the electro-magnet diminishes with it, and when the attractive force becomes weaker than the force due to the springs and gravity combined, the armature falls and the circuit is broken.

The adjustment on the Alfarata is such that the circuit is broken by the switch when the speed of the train is less than thirty miles an hour.

GILES TAINTOR.

O'KEENAN'S AUTOMATIC BATTERY.

THE reason that small installations of domestic electric lighting have not hitherto been greatly developed is especially because of the difficulties presented by the production of the electric energy necessary to supply small incandescent lamps, and such lighting has been met with thus far only in the houses of a few amateurs who are not discouraged by the operations necessary for the preparation of the liquids used in the piles, the frequent mounting of the batteries, and a certain number of other inconveniences that have caused the less bold to draw back, and have disheartened a goodly number of the most patient. But now, thanks to the progress made in the different branches of the applications of electricity, to the greater diffusion of electrical knowledge, and to the improvements made in the smallest details of apparatus, the question is changing aspect, and, after a personal experience of more than three years, we persist in believing more than ever in the future of the application of batteries to lighting houses by electricity, and such future will be a near one provided a few more practical inventions are made that are of the importance of the one that we are about to call attention to.

In order to estimate their value, it is necessary first to pass rapidly in review the different solutions of this delicate problem that have been proposed. They are divided into two distinct groups, according as it is a question of *direct* or *indirect* lighting. Batteries for direct lighting are innumerable, patents for them are taken out every day, and societies for working these patents are organizing month after month. Up to the present, the applications of these wonderful batteries have had but an ephemeral duration in practice, for reasons that our readers know. Their greatest inconvenience resides in the necessity that exists of effecting a maneuver near them every time that it is desired to light or extinguish a lamp. Batteries capable of remaining mounted and ready to operate, for a long time and without being touched, give, on another hand, but a feeble discharge, or are not sufficiently constant. They are especially adapted for temporary lighting of short duration, but they do not afford a lighting properly so called. Until we have discovered a constant, energetic pile, wasting nothing in open circuit, we must, except in a few exceptional cases, abandon the use of piles for direct lighting, and employ them only in an indirect way for charging accumulators of dimensions appropriate to the importance of the installation. In order to use piles at a maximum, it is necessary to have recourse to a flow of the liquid in order to make them continuous, and have them operate twenty-four hours a day. Bichromate of soda or potassa batteries are energetic and answer well for this service, but they have the inconvenience, already pointed out, of requiring a periodical preparation of the products—an operation that some dread, although we have been performing it for three years without any difficulty in our private installation.

It is necessary, then, to get up a powerful, automatic apparatus, of small size, capable of operating for a long time, almost without care and surveillance, and using only such products as are of simple manipulation and are without danger. After numerous experiments, this problem has been solved by Mr. O'Keenan in his continuous battery.

This apparatus is nothing else than the primitive battery of Daniell rendered practical and continuous. When once the apparatus is mounted, it is only necessary, in order to have it operate indefinitely, to lead pure water into it from a service pipe or a reservoir, to keep up a sufficient supply of crystals of sulphate of copper in a hopper, and to provide for a flow of the sulphate of zinc solution to the sewer.

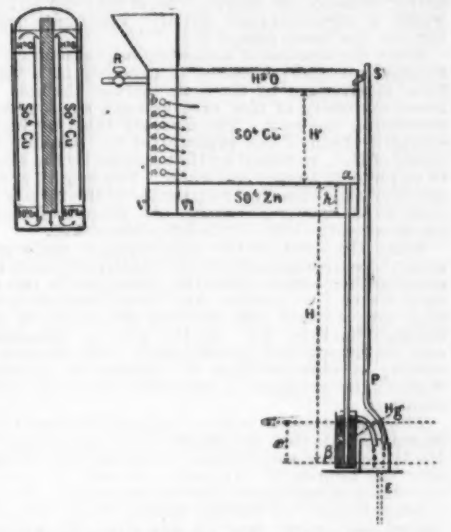


FIG. 2.—DIAGRAM OF THE BATTERY.

Fig. 1 gives a general view of a battery of ten elements in tension, designed for charging a series of three accumulators.

The ten elements are inclosed in an oblong trough of paraffined wood, the front of which consists of glass that permits the state of the pile to be seen at any moment. The dimensions vary with the discharge to be obtained and the number of the lamps. The model of medium size, here shown, is about four feet in height. The trough is divided into ten parts by wooden partitions. The front of each element contains a vertical slit designed to establish a communication between it and the space in front. At the left end there is a rectangular box containing small apertures and terminating above in a hopper, T, that permits of filling it with sulphate of copper. It will be seen that the water in the trough, on circulating through the apertures, comes into contact with the crystals and fills all the elements with a saturated solution of sulphate of copper. In each element there is a plate of zinc of very

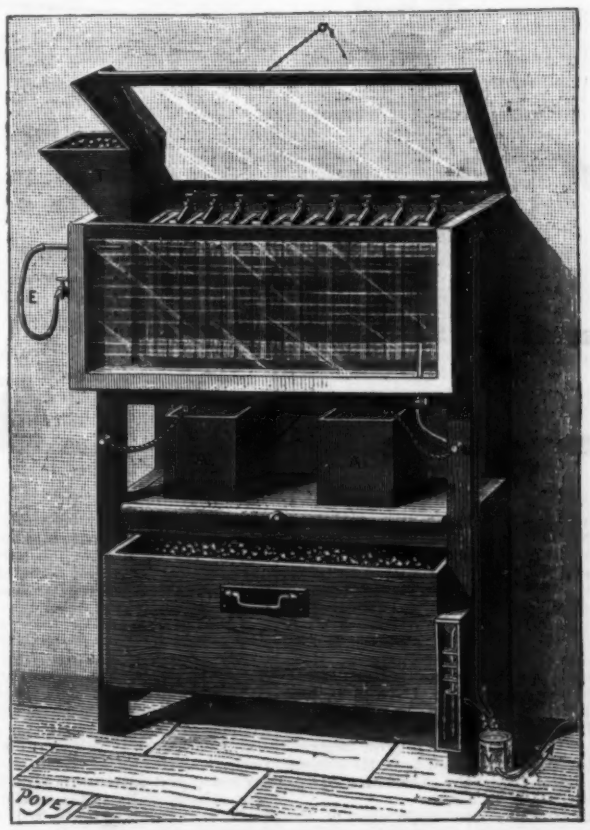


FIG. 1.—O'KEENAN'S AUTOMATIC BATTERY.

large size, inclosed in a sheath of parchment paper, and the sides of the box are provided with two lead plates upon which is deposited the copper formed by the reduction of the sulphate, while the denser sulphate of zinc formed falls to the bottom of the elements.

On allowing water to enter the upper part of the battery, drop by drop, three distinct and clearly separated strata are obtained. The first of these, which is of pure water, is but a few fractions of an inch in thickness. The thickest is formed of sulphate of copper, and is of the beautiful blue color that characterizes that salt. The third, which is yellowish, is a saturated solution of sulphate of zinc. In order to have a continuous operation, then, it suffices to introduce water into the battery through the intermedium of the cock, R (Fig. 2), which is regulated once for all. The excess escapes through the waste pipe, S P.

When the stratum of saturated sulphate of zinc has reached a certain thickness, it descends in a vertical tube, H, arranged at the lower part of the box. The lower extremity of this tube enters a small reservoir containing mercury. The mercury thus has its level changed through the pressure of the column of sulphate of zinc, increased by that exerted by the stratum of sulphate of copper and water. The height, *x*, of the mercury above the lower extremity of the tube is regulated so as exactly to balance the column of zinc sulphate when the level of the latter reaches *a*.

When the level of the zinc sulphate tends to rise above L, as a consequence of the batteries operation, the solution then escapes from the lower part of the tube, rises above the mercury, and flows through a waste pipe into a vessel that receives the excess of water through the tube, S P. At the time of mounting, if care be taken to put in sufficiently thick zinc plates, a battery is obtained that is capable of furnishing, without interruption, a constant current for several months.

The commutation is done by hand through the aid of simple bolts that are maneuvered once a day when the battery is visited, in order to put sulphate of copper into the hopper, T. It would be possible to use an automatic commutator, like Salomon's, and to employ a larger hopper, so that the battery would need to be visited only every four or five days, the automatic commutator effecting of itself the periodical coupling of the battery with the different accumulators. These latter, which are of the Julien type, of from 100 to 120 ampere hours' capacity, are placed under the battery. The shelf on which they rest is movable, and can be drawn forward in order to facilitate the surveillance of the accumulators and the keeping of them in order. —*La Nature.*

ELECTRO-METALLURGY OF ALUMINUM.

MESSRS. E. & A. H. COWLES, who, as our readers know, are now at the head of the electro-metallurgy of aluminum, have just improved their electric furnace in

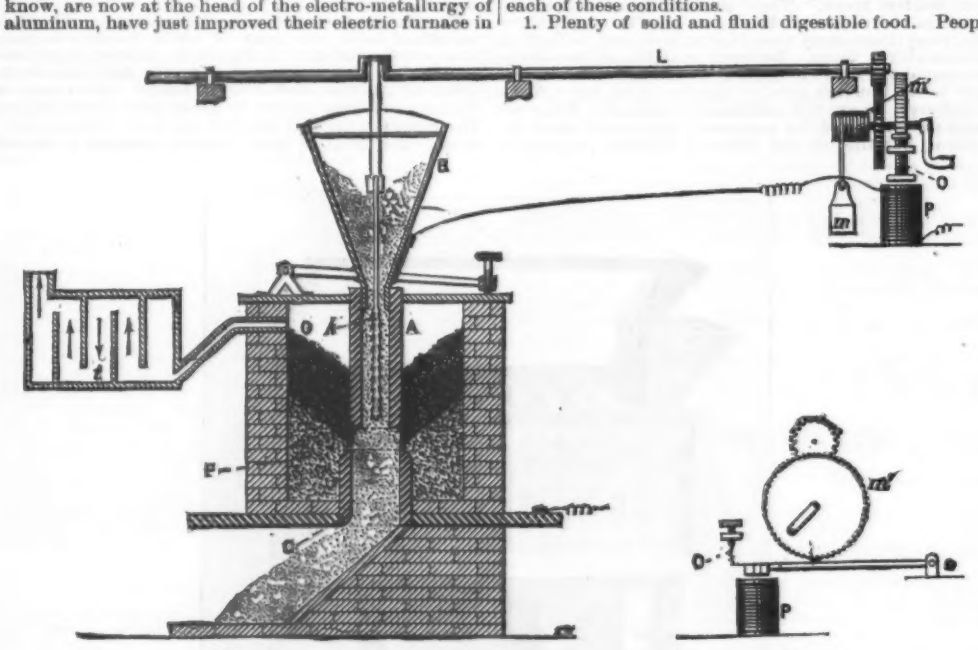


FIG. 1. FIG. 2.

such a way as to render its operation automatic and continuous, and to regulate the entrance of the ore proportionally to the fusion by means of variations in the electric resistance of the charge submitted to treatment. To this effect, as shown in Fig. 1, the mass of ore that passes from the hopper, B, to the furnace, through the positive and negative carbons, A C, is traversed by a carbon rack, *k*, which agitates it and facilitates its flow, as soon as the electro-magnet, P (in derivation on the circuit, A C), attracts its armature, despite the antagonism of the spring, O (Fig. 2), and thus permits the weight, *m*, by the ungearing of the wheel, *m'*, to move the shaft, L. As soon as, through too great a flow of ore, the resistance of the interval between the electrodes A and C descends to its normal value, the spring, O, pulls back the armature of the electro, P, and keys the shaft, L, anew.

It will be seen that in this new apparatus of the Messrs. Cowles the invariability of the resistance of the circuit of the electrodes is insured by the flow itself of the charge of ore, and not by the motion of the electrodes, whose spacing, when once regulated through the screw, J, remains invariable.

In this way, there is obtained a very active and continuous running that saves all the time that was formerly devoted to the filling of the furnace after each operation.

The furnace is lined with two strata of carbon, one of them, F, in fine compact powder, and the other, G, of larger pieces, allowing the gases that develop in the zone of fusion easily to escape to the condenser, *t*.—*La Lumiere Electrique.*

SIMPLE CONSTIPATION.

By Sir ANDREW CLARK, Bart., M.D., F.R.S., One of the Lecturers on Clinical Medicine at the London Hospital.

THE untoward consequences of constipation are always considerable and sometimes serious; but greater than they—greater than the anæmia, the blood poisoning, the headache, the nervousness, and the heart disorder which arise out of fæcal retention—are the untoward consequences of ignorant and unskillful domestic management.

For two days a patient has had no relief to the bowels. He has been traveling, or he has changed his diet, or his accustomed routine has been in some other way interrupted. The subject is seriously considered in the light of an excited self-consciousness, impending dangers are seen, and forthwith he determines to take "a dose." But the taking of doses is an inconvenient and a disagreeable procedure, and so it is settled that the dose shall be a good one—such a one as will speedily and effectually overcome the constipation and relieve the patient of his trouble. The dose is taken, the bowels (small, perhaps, as well as large) are emptied of their contents, the object of treatment has been achieved, and all for a time seems well. But the next day arrives, and there is no fresh movement of the bowels; even a second day passes, and they are still inactive. The patient is more uncomfortable than he was before he took his "dose." What is to be done? Matters cannot continue as they are. Plainly the medicine first employed has confined the bowels, and so another must be taken which shall be free from this disadvantage. The other is taken; again the bowels are freely moved, and a liquid, light colored, mucoid, and feculent discharge attests the success of the new endeavor. But the bowels fail to resume their periodical discharges; the patient becomes worse than ever; again he flies to artificial help for relief; again he is disappointed in recalling nature to her own ways; and at last the bowels, robbed of their normal conditions of action and exhausted by frequent irritation, refuse to act at all except under the spur of strong aperients frequently repeated. With few exceptions, no person has passed through this experience and fallen under the tyranny of aperients without finding his life invaded by a pack of petty miseries which lower his health, vex his temper, and cripple his work. Now, for the most part all these troublesome consequences of constipation may be avoided by attending to the conditions of healthy defecation. The chief of them requiring consideration at this time, and assuming the integrity of the nervo-muscular apparatus of the bowels, are plenty of solid and liquid digestible food, a fair amount of refuse matters in the colon, regard to the promptings of nature, daily solicitation at an appointed time, the co-operation of expectation and will, and contentment with a moderate discharge. I propose to discuss briefly each of these conditions.

1. Plenty of solid and fluid digestible food. People leading a sedentary or a society life become disposed to eat too fine foods and to drink too little liquid. Among the results of such habits are a general want of nervo-muscular vigor, a deficiency of intestinal secretion, and an insufficient amount of refuse matter in the bowels to secure daily relief. To correct this without the help of drugs, coarse and irritating foods are taken. For a day or two perhaps they succeed; but after a time they provoke catarrhal irritation, and either increase the constipation or bring about lienteric diarrhœa. As a rule, it is a practical error to treat constipation by means of hard, indigestible, and irritating articles of food.

2. A moderately full colon is essential to the sufficient periodical discharge from the bowels. It is true the ordinary peristaltic action of the bowels is automatic, and substantially independent of external stimulation; but it is, I think, equally true that for the stronger peristaltic action which, accompanied by inhibition of the associated lumbar center and relaxation of the anal sphincter, issues in normal defecation, an external stimulus, the stimulus of an adequate amount of retained fæces, is necessary. If by an aperient or by any other means the colon is more or less completely emptied of its contents, defecation will be suspended until the colon becomes again more or less full; it cannot act independently of the appointed conditions of action; it cannot make bricks without straw.

3. Regard to the promptings of nature. When the lower part of the sigmoid flexure is full, sensory impulses are sent to the nervous centers, and these are responded to by discharges which not only excite vigorous peristalsis in the upper part of the colon and solicit the co-operation of the will, but tend to inhibit the lumbar center and to bring about relaxation of the anal sphincter. The conditions of defecation are present, and it needs only a patient effort of will and concurrent expectation to originate and complete the operation. But when attention to these promptings of nature is denied, they cease for the time; and although they recur and suffice for action, the denial, if often repeated, blunts the sensibilities of the parts concerned, deprives us of the normal intimations of the need for relief, and brings about a form of constipation difficult to cure.

4. Daily solicitation of nature at an appointed time. It has been found that for the great majority of people the most favorable, and also the most convenient, time for procuring relief to the bowels is after breakfast, and it is one of the greatest helps to sufficiency and regularity of action that the daily solicitation of nature should be practiced at that time. In order that both solicitation and action should become developed into a habit, it is necessary that nature should not be listened to at any other than the appointed time. And in this precept there is no contradiction of the statement made in the previous paragraph; for it is not the temporary and exceptional denial of nature with the view of establishing a regular habit of defecation—it is the repeated denial of nature, with no such object in view, which blunts the reflex sensibilities of the parts concerned and brings about an obstinate constipation.

5. The co-operation of expectation and will. Many persons seek relief to the bowels without taking any pains to secure success. With some persons, indeed, such pains are unnecessary. A certain automatism has been established; and it needs only time, place, and position to set it in successful motion. But in persons whose defecation is difficult, direct attention, expectation, and effort are essential, and when patiently practiced seldom fail. The practice of slight alternate contraction and relaxation of the anal spincter sometimes provokes exceptionally active peristalsis of the lower colon; and so, with concurrent effort, secures relief which could not otherwise be obtained.

6. Contentment with a moderate discharge. Ignorance of the average amount of fæces required for the daily healthy relief of the bowels is one of the main causes of constipation, the unnecessary use of aperients, and the evils that arise from both. For a man of average weight, consuming an average amount of food, the average amount of fæces ready for discharge in twenty-four hours is about five ounces. This should be formed sufficiently aerated to float, and coherent. According as the cylinder is moist or dry, it will measure from four to six inches in length. Now, many people expect to have a much more abundant discharge, and are dissatisfied or anxious if they do not get it. They complain of their insufficient relief, and take aperients to make it larger. For a day or two larger discharges are procured, but then, when the reserves of fæces are removed and the colon is empty, and the conditions of defecation no longer exist, more or less complete inaction of the bowels ensues, constipation (as it is here erroneously called) becomes confirmed, new and stronger aperients are had recourse to, and at last the patient falls into a pitiable condition of physical suffering and moral wretchedness. And from this condition there is no escape except through the complete suspension of aperients, the renewal of obedience to physiological laws, and a courageous patience in waiting upon nature.

I will conclude these imperfect remarks by putting down as briefly as possible the instructions which I ask my pupils to give to their patients for the management of simple constipation: 1. On first waking in the morning, and also on going to bed, at night, sip slowly from a quarter to a half a pint of water, cold or hot. 2. On rising, take a cold or tepid sponge bath, followed by a brisk general toweling. 3. Clothe warmly and loosely; see that there is no constriction about the waist. 4. Take three simple but liberal meals daily; and, if desired, and it does not disagree, take also a slice of bread and butter and a cup of tea in the afternoon. When tea is used it should not be hot or strong, or infused over five minutes. Avoid pickles, spices, curries, salted or otherwise preserved provisions, pies, pastry, cheese, jams, dried fruits, nuts, all coarse, hard, and indigestible foods taken with a view of moving the bowels, strong tea, and much hot liquid of any kind, with meals. 5. Walk at least half an hour twice daily. 6. Avoid sitting and working long in such position as will compress or constrict the bowels. 7. Solicit the action of the bowels every day after breakfast, and be patient in soliciting. If you fail in procuring relief one day, wait until the following day, when you will renew the solicitation at the appointed time. And if you fail the second day, you may, continuing the daily solicitation, wait until the fourth day, when assistance should be taken. The simplest and best will be a small enema of equal parts of olive oil and water. The action of this injection will be greatly helped by taking it with the hips raised and by previously anointing the anus and the lower part of the rectum with vaseline or with oil. 8. If by the use of all these means you fail in establishing the habit of daily or of alternate daily action of the bowels, it may be necessary to take artificial help. And your object in doing this is not to produce a very copious dejection, or to provoke several smaller actions; your object is to coax or persuade the bowels to act after the manner of nature by the production of a moderate, more or less solid formed discharge. Before having recourse to drugs, you may try, on waking in the morning, massage of the abdomen, practiced from right to left along the course of the colon; and you may take at the two greater meals of the day a dessertspoonful or more of the best Lucca oil. It is rather a pleasant addition to potatoes or to green vegetables. 9. If the use of drugs is unavoidable, try the aloin pill. Take one half an hour before the last meal of the day, or just so much of one as will suffice to move the bowels in a natural way the next day after breakfast. If it should produce a very copious motion, or several small motions, the pill is not acting aright; only a fourth, or even less, should be taken for a dose. When the right dose has been found, it may be taken daily, or on alternate days, until the habit of daily defecation is established. Then the dose of the pill should be slowly diminished, and eventually artificial help should be withdrawn. The aloin pill is thus composed: ℞. Aloinæ, ½ gr.; extr. nucis vom., ½ gr.; ferri sulph., ½ gr.; pulv. myrrhæ, ½ gr.; saponis, ½ gr.;

flat pill., 1. If the faces are dry and hard, and *if there is no special weakness of the heart*, half a grain of ipecacuan may be added to each pill. Should the action of the pill be preceded by griping and the character of the action be unequal, half a grain of fresh extract of belladonna will probably remove these disadvantages. If the aloin pill gripes, provokes the discharge of much mucus, or otherwise disagrees, substitute the fluid extract of cascara sagrada, and take from five to twenty drops in an ounce of water either on retiring to bed or before dinner. And when neither aloin nor cascara agrees, you may succeed by taking before the midday meal two or three grains each of dried carbonate of soda and powdered rhubarb.

The exact agent employed for the relief of constipation is of much less importance than its mode of operation. If, whatever the agent may be, it succeeds in producing after the manner of nature one moderate formed stool, it may be, if necessary, continued indefinitely without fear of injurious effects. But, treated upon physiological considerations, I have the belief that in the great majority of cases simple constipation may be successfully overcome without recourse to aperients.

THE STATUE OF VOLTAIRE AT SAINT CLAUDE.

How many statues of Voltaire are there? It would be interesting to know the number of bronzes and marbles that have been consecrated to the memory of the author of the *Contes*. And, in the enumeration, it would not be necessary to enumerate only the statues that ornament our public gardens and parks, but it would be necessary to take into account those also that are the property of incorporated bodies, and that are not at every hour exposed to the gaze of the profane. This enumeration has already been made for Paris, and has demonstrated that of the monuments consecrated to great men, those of Voltaire take the lead in number.

The memory of this great man has just been honored by still another monument, which was inaugurated Sept. 4, at Saint Claude (Jura). This time it is not a question of a political or philosophical manifestation, but it is a debt of gratitude that the inhabitants of the Jura wanted to discharge without further delay. They remember that during the continuous production of his *chefs d'œuvre* he whom Frederick the Great had called King Voltaire found time to lift his voice in behalf of the serfs of the Jura, who were so unjustly deprived of their liberty, and lowered to the level of cattle, and that, too, in the eighteenth century. In fact, it was the custom, and, so to speak, the law, that every stranger who stayed a year upon the lands of the abbey of Saint Claude became, by that fact alone, a serf thereof.

The protestations of Voltaire were heard. Louis XVI. hastened to abolish this shameful privilege in part, and the revolution finished the work of humanity. The sculptor, Mr. Syamour, has associated with the memory of the great writer that of the lawyer Christin, whose bust is placed in the pedestal of the statue. Christin, who was a member of the constituent assembly, took an active part in this freeing of the serfs of the Jura. He was a native of Saint Claude. Voltaire protested, it is true, and demanded justice for the serfs, but it was Christin who upheld the cause of the latter before judges whose ear was not always favorable to the adversaries of certain privileges. We borrow our engraving from *L'Illustration*. The same journal of a more recent date gives an account of an attempt made a few days after the inauguration to overturn the statue. Under the cover of night, a number of persons provided with ladders and poles wound a rope around the right arm of the statue, and, while some of them held the rope, the rest, armed with a lever twenty feet in length, tried to pry the bronze off its base. This took place by the light of a lantern that one of the iconoclasts held. Before doing anything, they took care to remove all the crowns deposited at the foot of the statue, and threw them pell-mell under a bridge in the vicinity.

The scoundrels did not succeed in their enterprise, as the bronze was too solidly sealed into the stone, so they dispersed on the arrival of some chance pedestrians, but not without leaving upon the pedestal a placard uncomplimentary to Voltaire, whose statue, notwithstanding all that, preserves its skeptical and scoffing smile.

APPEARANCE AND REALITY IN PICTURES.

By Dr. EUGEN DREHER.

IN the contemplation of the creations of the painter, the mind is stimulated to a degree of activity which the enjoyment of no other form of art work can induce. A mental operation is provoked of which we are hardly conscious, and which some have attributed to the organization of the visual apparatus, that amounts in effect to the transformation of the flat surfaces of the picture into the appearance of a body or a group standing out or receding in relief. The inquiry as to how the painter can invoke this illusion is usually answered by saying that he knows how to represent objects in perspective; that is, that he is able to arrange the lines of the picture—except that the image is not reversed—so that the adjustment shall correspond essentially with that of the image which is cast upon the photographer's screen or upon the retina of the eye. The process, unperceived and instantaneous in the case of simple objects, by which such representations are given bodily projection, may be followed out in its gradual development in contemplating pictures of a more complex character, as, for instance, a view of the interior of a grand cathedral. Without any change taking place in the image on the retina, the individual objects are gradually lifted one from another; those represented as in the background appear to become larger, but at the same time obscure, and those in the foreground to grow smaller, but more sharply defined. Thus the size we attribute to the objects depends upon the distance we assign to them as well as on the visual angle they subtend. There are, according to this, unconscious processes that fit us for seeing plane surfaces as bodies, provided the picture furnishes suitable points to which our conceptions of corporeal projection may attach themselves. To see a perspective representation of a cube, I must have remaining within me a conception of a cube already acquired by the exercise of my senses; and, without such an acquired conception, the picture would still be to me only a picture or a planimetric feature, without projection. Hence we find that, in looking at pictures, unconscious representations intrude upon the primary conceptions, and change them into secondary ones, by means of which a surface is made to look like a body having projection. This process occurs in all monocular vision, when we interpret the flat retinal image corporeally.

To obtain a proper appreciation of a perspectively correct picture, we must look at it with one eye; for, in looking with two eyes, the duplication of the visual lines that define the position of each point as it is perceived must cause more or less of the impression of the really plane surface to persist. In this case the corporeal projection becomes confused with the superficial conception, and is more or less modified by it. The effect of perspective is also heightened by looking at the painting through a tube, by means of which it is abstracted from the frame and from its surroundings.

We observe, also, in looking at a picture, the curious phenomenon that, whatever position we may take toward it, it always appears projected, but in aspects which are varied not only in respect to the absolute position of its constituent parts, but also in respect to their mutual relations with one another, to such an

STATUE OF VOLTAIRE AT SAINT CLAUDE.

extent that from an extremely unfavorable position it appears distorted.

Whenever an artist cannot produce the perspective effects he desires in a picture drawn with absolute correctness, he does not hesitate to exaggerate the perspective if he thinks he can thereby enforce a better conception of his design. He represents distant objects on a smaller scale than strict accuracy demands, and causes us, by unconsciously taking account of the reduction, to see them farther off than we otherwise would do; and he knows how to call our imagination to his help in other ways.

Although the application of perspective devices is usually enough for the purpose, the projection of the design is heightened to a considerable degree, facilitated, and brought nearer the appearance of reality by the introduction of effects of light and shade. This also is borrowed from nature. The shading may, indeed, sometimes define and fix the effect which mere perception fails to convey positively. A square with two diagonals drawn across it may mean simply that, or it may be intended to represent a pyramid. If proper shading is added, the figure is made to mean a pyramid unmistakably.

If we assume that the light is evenly diffused through any space, then, other conditions being equal, those things in the space which are nearer to us will be clearer in appearance in a proportion determined by the rule that the intensity of light diminishes as the square of the distance increases. A point twice as far from the eye as another appears four times as obscure. This normal diminution of intensity is augmented by the darkening which objects undergo in consequence of the interposition of strata of air, or by the effect of "air perspective," as it is called, in distinction from linear perspective. The painter must take both of these phenomena into account. By the application of a suitable coloring, the effect of air perspective may be produced in so striking a degree that objects may, by means of it, be made to appear wonderfully remote. This effect, also, is dependent upon our unconscious application of knowledge we have gained from previous experience.

The shadow which all objects cast when exposed to any kind of light is a capital sign of bodily substance. Our conception of bodies is inseparable from that of their shadows. The importance of this phenomenon as an aid to projection is illustrated by the manner in which through them flat letters on signs are made to appear standing out as solid bodies.

The painter is also able to represent motion by taking advantage of the unconscious working of our preconceived impressions. Looking at a masterly marine landscape in the National Gallery at Berlin one day, I could almost see the ship rising and falling upon the waves, and the waves themselves seemed to be in motion as they swelled and swept by the vessel. The painter had seized a single instant in the succession, and had so represented it as to call out the idea of consecutiveness. The question arises, How is the artist to illustrate motion, as he often has to do, say in such a case as that of a rapidly turning wheel, in which we can at no instant distinguish the single spokes, but see only a confusion of flying lines? It is clearly impossible for him to give the exact appearance of motion. He can only seize a given instant or stage, and so manage that it shall represent itself as the effect of the preceding stage and the cause of the following one. A sword blow must be represented at a decisive point, not at a stage in the descent of the weapon, else the illusion will be destroyed; a pendulum in motion, not at the bottom of its course, where it would seem to be at rest. In painting a galloping horse, no stage of the exact motion is reproduced. The instantaneous photographs have demonstrated that; and also that, if the artist should attempt a reproduction of the kind, he would give any but the effect desired. He makes a more pleasing and probable picture, having, however, no counterpart in nature, in which he does no violence to her, but, as Schiller has said, "increases the nature that is in nature."

The theory of color perceptions is not yet far enough advanced to permit a full explanation of all the phenomena of coloring; still, it is competent in its present condition to give valuable hints concerning the color effects experienced in the contemplation of paintings.

All the variations in color perceived in nature may be produced from red, yellow, and blue, or, as others have it, from red, green, and violet, and their combinations. The painter does not possess any of these colors in their purity, but always adulterated with more or less that is foreign to them, and can hardly ever reproduce the exact color he finds in nature, and it is his task to combine the materials he has so as to give as near as possible an approach to them. How does he, with the deviations he is forced to make, bring about the magic illusion that causes us to perceive in his creations the same endless play of light and color that nature so lavishly bestows upon her pictures? How does he reproduce the burning glow of the setting sun and the objects it illuminates? He does it by means of a contrast of colors, in which particular shades are given a changed appearance to our perceptions by backing them one against another. When, for instance, a tolerably clear red and a tolerably pure green are put together, both colors appear to undergo a change, and to gain in purity; or, in popular language, the red seems to become redder and the green greener. This proceeds from two causes, one of which is purely mental, and consists in the heightening of the contrast between the two colors when they are brought into comparison with each other; while the other is physical, and depends upon a kind of fatigue which the nervous fibers suffer in consequence of the higher activity which the presentation of the contrast develops in them. As the perception of the red becomes wearied, that of the green becomes more acute, and *vice versa*, and the two in this manner react upon each other. By a similar process, white reposing upon black appears clearer and purer, while the black seems deeper and darker.

A painter, having to introduce two kinds of light, daylight and candle light, into his picture, would not be able to represent directly the contrasts which the struggle between the two kinds of light calls forth in nature, because his colors are so inferior in intensity to the reality. He has to paint the effect in by making the daylight relatively bluer and the candle light more of a red yellow than in nature. He thereby leads us, after an interval, to an illusion of the same character with that which nature, by the superior intensity of its light, produces in a moment.

In like manner, the painter, by exaggerating the illumination of his objects, reproduces similar effects to those which nature gives with the full brilliancy of its light; as, for instance, the glow of the snow fields of the Alps, which the beams of the evening sun clothe as with a garment of fire, in contrast with the dark blue vault of the sky above them, and with the valleys already hiding themselves in the shadows of night. In all these cases the action of nature is made more speedy than that of the picture, because the light at its disposal is so much stronger, but the effect of both is in the end of the same character, and the seeming becomes clothed with reality.

The painter must, furthermore, give effect to other color perceptions which are wholly conditioned upon the organization of the eye. These are the subjective conceptions that show forth the complementary colors. By this term are meant those colors which in combination produce white, as red and green, blue and orange, yellow and violet. The complementary tint also appears after the eye has become fatigued in looking at a particular color, as when the eye has been gazing at green, it turns to a white spot and appears to see it red.

The complementary effects may frequently be observed in nature. Parts of the sky between bright red clouds sometimes appear green; and the ground of a wood, the bright green foliage of which glitters in the sunlight, looks rose colored. The painter has to take these phenomena into consideration, and, making due allowance for the weakness of his pigments, to incorporate the apparent tints into his picture. Here, again, what nature with her vivid colors does in an instant the artist has to bring about more slowly; but the illusion is complete in both cases from the moment our conceptions are brought into accord with it.

There is, furthermore, something in the colors of natural objects which is distinct from the strength and clearness of the illumination, and appears peculiar to

certain kinds of light. Among such peculiarities are the metallic luster, the silken sheen, and opalescence, which, although they all proceed from combinations of the spectrum colors, have not yet been sufficiently investigated to enable us to determine all the circumstances contributing to produce them.

The colors used in painting afford little that is analogous with these lusters. Can the painter produce these effects also by contrast? They appear in pictures by the most eminent masters to be reached almost in perfection. If, however, we inquire whether the painter can reproduce the peculiarities of luster and color which we admire so much in nature through the contrast of his colors alone, we shall have to admit that he calls other elements into play.

We have already shown how our conceptions of the relations of objects in place are influenced by our unconscious prepossessions. May not these also intrude themselves upon and modify our conceptions of the color and tone of the picture? The connoisseur who has frequently observed the shimmer of the sea, and who has followed with a finely developed perceptive power the transformations of the landscape under a changing light, and who has been in the habit of watching in an æsthetic mood the combination and grouping of the individual features of nature, is doubtless better able to realize these peculiarities also in works of painting than he who applies only a sharp but untrained discernment to the gradual development of the idea of the picture.

Thus art, temporarily withdrawing us from nature by substituting her own creations for the reality, brings us back to nature as the inexhaustible source whence all its elements are borrowed; and the imagination, also, in its own way, is able to make use of those elements for new creations.—*Translated for the Popular Science Monthly from Die Natur.*

[Continued from SUPPLEMENT, No. 616, page 9843.]

PLANT ANALYSIS AS AN APPLIED SCIENCE.[1]

By HELEN C. DE S. ABBOTT.

VEGETABLE WAX is found on the surface of leaves, on the stem and the berries of plants, and is obtained from many sources. The commercial supply comes from certain species of the palm tree family in considerable quantities. Carnauba wax is from a large Brazilian palm. *Myrica*, or myrtle, wax comes from the berries of an American and Mexican plant, *Myrica cerifera* of the *Myricaceæ* family, and Japan wax is obtained from *Rhus succedaneum*.

Vegetable wax[2] is principally used in the manufacture of candles, but on account of its greater dryness, it breaks much more readily than animal wax; hence, if animal wax is mixed in small proportions with vegetable wax, it answers very well. It is also used in adulteration of beeswax. Cerosin,[3] a wax from sugar cane, is said to melt at 82° C. It has been proposed, on account of its high melting point, to use it in the manufacture of candles. Five hundred plants can furnish, it is claimed, one kilogramme of wax.

The bark of *Fonquieria splendens*,[4] or the ocotilla tree of Mexico, also yields a wax. The native Indians use this stem for illuminating purposes; it burns with a red, smoky flame, and is called the candle tree.

The vegetable waxes are mixtures of resinous substances and the higher fatty acids, and differ from the fixed oils in containing, in place of glycerine, cetyl, ceretyl, and myricyl alcohols. Properly they contain ethers of higher alcohols of the ethylic series and free acids. The wax obtained from the *Gramineæ* or grasses, to which class sugar cane belongs, has been studied by Konig:[5] he found that it contained no glycerine, but cholesterin, cerotic, palmitic, and oleic acids.

The importation of vegetable and mineral wax[6] for 1884, 617,992 pounds ($69,026); 1885, 1,056,438 pounds ($1,123,976).

The oils of vegetable origin used in commerce[7] are usually derived from grains. A few only are extracted from the fleshy parts of fruits. The oil is found in the form of minute drops in the rinds of fruits. The orange contains four different oils, and in many seeds the absence of starch is replaced by oil, and serves the future seedling for nutrition. The oil is usually obtained on a large scale by pressure. However, oils are soluble in petroleum ether, and may be extracted by it. In France,[8] the cultivation of oil-yielding plants occupied 445,000 hectares, the product of which amounted to 105,000,000 francs. Olive oil[9] is obtained from several species of the olive tree. It serves for many purposes, and enters into the food of some nations. In Spain, a kind of soup, made of oil, garlic, and bread soaked in water, is eaten by the poorer classes.

The nuts[10] of *Carylus avellana* give an excellent table oil. It is also used in perfumery. The residue from the extract is used for almond confection, and is preferable to that made of ordinary almonds. A commerce is made in China of "Chou-lah,"[11] obtained from one of the *Euphorbiaceæ*. This tallow is made into candles, which burn with a brilliant and white flame. There is an enormous demand for them. Many other plants of the same family furnish this oil. The genus *Bassia*, of the *Sapotaceæ* family, yield several important fats, among which is one known as Galam butter. This vegetable butter can replace animal fats, and is largely used in soap making. The annual report of the manufacturers of linseed oil alone for one year was figured at high rates, but the manufacture and uses of this oil are too well known to need more than a mention.

Olive oil in the *American Pharmacopœia* is replaced by cotton seed oil.[1]

The supply of cotton seed—*Gossypium*—is obtained from several countries, and may be said to be inexhaustible. The Southern States of North America contribute the largest quantity by millions of tons. A large proportion is not worth the expense of transit, and is burned for fuel and given to stock for litter. A considerable quantity is used in the manufacture of decorticated cotton cake and oil. Egypt is said to grow a superior quality of seed, and England derives her principal supply from there. Improvements in the method of irrigation are said to have increased the annual quantity, but the average of past years has been about 250,000 tons.

The seeds yield some twelve to twenty per cent. of oil. The oil in appearance, taste, and smell resembles fresh olive oil.

The fixed oils are chemically glycerides and are principally composed of glycerine, in combination with oleic, palmitic, and stearic acids. They are frequently solid at ordinary temperature, and their consistency depends upon the proportion of oleic acid present.

Commercial oils[2] frequently contain free acids; thus in palm oil the free acid calculated as palmitic acid usually varies from twelve to eighty per cent. The presence of free acid in an oil is doubtless the principal if not the only cause of its tendency to act on metals, and therefore seriously affects the suitability of an oil for use as a lubricant.

Before leaving the subject of vegetable oils, I wish to call attention to the essential oil industry in Grasse.[3] The world-wide fame of this locality depends upon the essential oils of plants which grow wild or are cultivated in the neighborhood. The oil of lavender, rosemary, the garden thyme, of the *Labiatæ* family afford an important export industry of Grasse.

The following quantities of oil are delivered in Grasse every year: From the lavender, 80,000 to 100,000 kilogrammes; from thyme, 40,000; and from rosemary, 20,000 to 25,000 kilogrammes. The quantity sent out from Grasse probably meets the requirements of the whole world. Dalmatia only furnished the oil of rosemary, and sends about 20,000 kilos of this essential oil into the market. Grasse also sends forth each year oil from the citrus species, especially oil of neroli, which is much esteemed. Orris butter is distinguished above many other perfumes by an agreeable softness and great permanence. One of the houses in Grasse prepares four to ten kilogrammes yearly. Its value in Grasse is 1,500 to 1,800 francs the kilo. Besides the wholesale distillation of orange flowers and roses, some other aromatic plants are occasionally worked up when needed, though not to any great extent.

The processes used for extracting these perfumes by the methods of "infusion" and "enfleurage" are extremely interesting, and may deserve a passing notice. The fat used as the basis of the "pommade" is selected from the best pig's lard or beef suet. The melting, its mechanical purification, and washing are conducted with great care. The stability of the fat is increased by its digestion with benzoin. The "infusion" is effected in large jacketed boilers, in which the fat is warmed by steam heat and the flowers are added. In the month of May over 10,000 kilos of rose or bigarade flowers pass daily for many successive days into the boilers of the factory of one house alone. The fat is diligently stirred by female workers; the expression, by means of hydraulic presses, is done by men. After the clearing of the fat, the finished "pommade" is at once weighed and stored in tin boxes.

In the case of the more delicate perfumes, the above method of "infusion a chaud" is replaced by "enfleurage." For this purpose light square wooden frames, about eighteen inches each way, in which a plate of glass can be placed, are used. Upon each glass is spread a quantity of fat in a thin layer, and this is strewn thickly with flowers. Sometimes contact with the fat is avoided, and the layer of fat is confined to the other glass wall of each compartment. When a perfumed oil is desired, cloths saturated with oil for the "enfleurage" may be used. The flowers are shut up in these glass compartments for a longer or shorter time, and are repeatedly renewed and replaced by fresh ones. The perfumed fat is mixed with alcohol by means of powerful stirrers. The alcohol takes up scarcely any of the fat, but the greater part of the odorous substances.

From several trials, I think these processes of extraction may be applied to extract the delicate odors of barks and other substances which would be destroyed by distillation, and have escaped detection up to this time.

Among the chemical substances recently introduced into the field of chemical industry[4] may be mentioned cholesterin, or lanolin, $C_{26}H_{44}O + H_2O$. Commercially, this substance is obtained from animal sources, but its wide distribution through the vegetable kingdom warrants its mention in this place. The singular property of this substance and its promising commercial future deserve more than a passing notice. Liebrich observed that cholesterin fat possesses the peculiar property of being able to absorb more than 100 per cent. of water, and this singular property was denominated by the great pharmacologist, lanosation, while the cholesterin, mixed with water, was termed by him, lanolin. He also first called attention to the great therapeutical value of lanolin, and shortly afterward the industrial production of pure lanolin was commenced by a Berlin firm,[5] and its manufacture has been of late steadily increasing.

Lanolin is already taking the place of vaseline, paraffine, and lard. Its efficacy has already been established beyond doubt, and its superiority is due to the extraordinary readiness with which it is absorbed by the skin. This property is not known to belong in a similar degree to any other fatty substance. Besides the medicinal use, it has also been already introduced into various branches of industry, such as perfumery, soaps, and pomades, also for greasing leather belting and for improving the pliability of leather.

The history of the wholesale drug trade for the year 1886 is one of the most remarkable on record since 1879–80. In a late number of the *Druggists Circular*,[1] a summary is given of the year, from which I have taken some statements.

From the table of prices, as follows:

	January 1.	December 15.	July 1.
Alcohol	$2.10	$2.17	$2.09
Camphor	23	22.25	23
Gum arabic	70	95	83½
Morphine	2.35	2.10	1.90
Vanilla bean	10.00	18.00	12.00
Copaiba balsam	34	36	34
Cubebs	90	1.35	95
Tragacanth	45	42	37½
Senna leaves	15	27½	30
Golden seal	14	18	13
Pink root	35	47½	60

The advance in alcohol is said to be the result of a combination among the distillers. Balsam copaiba has for a long time been very scarce, but the arrival of new stocks will make it freer. "Cubebs, vanilla beans, gum arabic, tragacanth, senna, golden seal, serpentaria, and pink root have been and are still very scarce and are likely to be higher. . . . The largest movement in cocoa leaves ever known, took place early in the month. . . . A short crop of senna coming at a time when all markets were poorly supplied, and during an unusually active period, is responsible for the upward movement of the drug. . . . The position of quinine just now is an interesting one, and the future of the market depends upon the source of barks, and that at present is expected to be upward, owing to reduced visible and prospective supplies."

The commercial value of these drugs depends upon certain chemical compounds which they contain. The scarcity of some of these drugs in itself is a sufficient inducement to push forward investigation in plant chemistry, and to endeavor to discover the same valuable constituents or their equivalent in new plants.

The preparation of fine prescriptions has been advanced by the perfection in chemical methods of isolating plant constituents. The medicinal value of many drugs is due to one or more principles, and to be able to administer these principles apart from the accompanying compounds of the plant is a triumph of analytical skill.

A new and convenient form to prescribe the more important alkaloids, glucosides, and other active plant principles is offered by Frederick Stearns & Co., Detroit, Mich. This firm manufactures alkametric granules and alkadermic pellets. These granules contain carefully prepared medicines representing the pure alkaloid or active principle.

The enormous quantity of drugs used to furnish alkaloids or other medicinal principles may be seen from the import[2] of cinchona bark or other barks used in the manufacture of quinine:

	Pounds.	Value.
1884	2,588,307	$718,035
1885	3,559,691	913,189
Of sulphate of quinia:		
	Ounces.	Value.
1884	1,263,732	$1,610,163
1885	1,390,126	1,292,794
Other salts of quinia:		
	Ounces.	Value.
1884	712	$1,038
1885	5,435	1,868
Cinchonidia:		
	Ounces.	Value.
1884	381,885	$206,405
1885	478,747	220,846

A New York firm[3] has recently introduced upon the market quint-essential oils. The odorous principle of these oils is due to the stearoptens or camphors, which readily separate from the more volatile portions.

It has been suggested, owing to the scarcity of gum arabic, to introduce upon the market a gum[4] from a Mexican tree, called the mesquite. This gum exudes from the stem and branches during the summer months. The analysis of this gum offers several interesting features. Among others its solutions can be combined with basic lead acetate and ferric salts without being precipitated, and it is suggested for this reason the more applicable in medicine than in gum arabic. It is probable that in time gum mesquite will become a commercial article of importance.

We are indebted to plants for our tea, coffee, and chocolate supply, and these articles may be reckoned among our foods, for one or all are used by every people.

In Spain, chocolate is looked upon as a necessity. The Spaniard may be seen making his early breakfast with a slice of bread spread with a thick paste of chocolate. The smiling-faced "El cocinero" told me how he prepared it, by carefully melting the solid chocolate cake to the desired consistency. A cup of steaming hot goat's milk is offered to the traveler to mix with this chocolate if he is unable to take it straight.

"When Cortez and the Spaniards entered the vast empire of Montezuma, they found the use of cocoa or chocolate as a beverage common. The emperor alone drank it flavored with vanilla from a golden cup."[5] The Spaniards very jealously guarded as a secret the mode of chocolate manufacture, and were able to retain the monopoly of the trade for many years.

Theobromine, caffeine, and theine are the alkaloids which give cocoa, coffee, and tea their exhilarating properties. They owe their aroma to certain volatile oil, which in the case of cocoa is probably developed by roasting.

Tea[6] is of the utmost importance as an article of consumption, and far exceeds in demand cocoa or coffee. Tea can be grown in a wide range of climate—in Pekin with winters of Russian severity to Canton and Macao. Any country having a long and hot summer and a cold winter can grow tea. The proportion

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[1] A lecture delivered before the Franklin Institute, January 17, 1887. From the *Journal of the Franklin Institute*.

[2] Matieres Premieres Organiques. Par Pennetier, p. 771.

[3] Matieres Premieres Organiques. Par Pennetier, p. 771. Annales de Chimie et de Physique, lxxv., 218. Annal. d. Chem. und Pharm., xxxvii., 170, 1841. Ibid. (new series), xiii., 451.

[4] Proc. A. A. A. S., vol. xxxiii. Amer. Jour. Phar., Feb., 1885. The analysis of this plant is among the first published accounts of plants treated by Dragendorff's scheme in this country.

[5] Landw. Versuchsstat, xiii., 341.

[6] Bureau of Statistics, Treasury Department, 1885.

[7] Loc. cit. Pennetier, p. 706.

[8] Ibid., p. 709.

[9] Pennetier, p. 709.

[10] Pennetier, p. 750.

[11] Ibid., p. 752.

[1] "Notes on Cotton Seed Oil." By W. Gilmour. Am. Jour. Pharm., Nov., 1885, p. 565.

[2] Commercial Organic Analysis. By A. H. Allen. Phila., 1887. Vol. ii., p. 26.

[3] F. A. Fluckiger, Amer. Jour. Phar., March, 1886, p. 137.

[4] "Notes on Chem. Substances recently introduced into the Field of Chem. Industry." By J. Levinstein. *Jour. Soc. Chem. Industry*, Nov. 29, 1886.

[5] Messrs. Jaffe & Darmstadter.

[1] *The Druggists Circular and Chem. Gazette*, Jan., 1887.

[2] Bureau of Statistics, Treas. Dept.

[3] Fritzsche Brothers.

[4] "Products of the Mesquite." By H. J. Schuchard. *Amer. Jour. Pharm.*, Nov., 1885, p. 542.

[5] *Tropical Agriculture*. By P. L. Simmonds. London, 1877. P. 2.

[6] Ibid., p. 79.

per head of consumption for Great Britain and Ireland during 1875 was 4·44 pounds.

The very best workers in gathering the tea leaves rarely earn as much as sixpence a day, and until other nations can raise tea for six cents a pound, they cannot compete with China in its production.

Guarana, a product allied to cocoa, maté, or Paraguay tea are also used. The same or allied alkaloids prevail in all the principal substances employed for these beverages in different parts of the world. After tea, there is scarcely any other staple of commerce used for dietetic beverages more generally acceptable with all classes than coffee.

The statistics of cocoa, tea, and coffee.*

IMPORTED INTO THE UNITED STATES.

Tea:

	Pounds.	Value.
1884.....	65,774,234	$13,504,798.56
1885.....	69,820,172	13,725,380.75

Coffee:

	Pounds.	Value.
1884.....	532,514,850	$49,685,689.30
1885.....	572,222,841	46,733,290.16

Leaves and shells of crude cocoa:

	Pounds.	Value.
1884.....	12,263,948	$1,673,088.00
1885.....	10,300,078	1,332,375.00

The above facts, including the tables of statistics, show the extent of our dependence on the presence of chemical compounds in the various plant sources, from which we derive many of our supplies.

(To be continued.)

THREE DAYS AT THE SUMMIT OF MONT BLANC.

MR. JOSEPH VALLOT, one of the most daring members of the Alpine Club, after making a series of physiological observations in 1886, during an ascent of the highest peaks of the Alps, resolved to establish three observatories on Mont Blanc, the first at Chamouny (3,444 feet altitude), the second on the rocks of the Grand Mulets (10,000 feet altitude), and the third on the very summit of Mont Blanc (15,500 feet altitude). He had the proper structures put up, and provided each of them with a registering barometer, thermometer, and hygrometer, made by the Richard Brothers.

FIG. 1.—ASCENT OF MONT BLANC.

The apparatus placed at Chamouny and on the Grand Mulets were designed to be inspected every week, and those on the summit were to be visited every fifteen days. Moreover, Mr. Vallot provided the Chamouny station with a series of direct-reading instruments, and proposed to spend three days on the summit with similar apparatus in order to make simultaneous observations at the altitudes of 15,500 and 3,444 feet. Mr. Vallot's bold project was regarded as impracticable at Chamouny. He carried it out, nevertheless, in company with Mr. F. M. Richard, who, at our request, has given us the following account of the voyage.

It took no less than twenty-five guides to carry the camping equipment, the baggage weighing 550 pounds. The ascent to the Grand Mulets was effected on the 27th of July, 1887. We shall now let Mr. Richard speak for himself.—*La Nature.*

Starting from the Grand Mulets, the ascent is difficult, but relatively free from danger when the snow is good. There are but few crevasses that have to be crossed by ladders, and then there are endless banks of snow, very steep and very fatiguing. On reaching the Great Plateau, at 7 o'clock, every one stopped to take a little food and rest. Meanwhile, the sun was high on the horizon, and the ascent became more and more difficult. Passing the Dromedary's Humps, we reached Tourette Rock. Here one of the porters was obliged to stop, and, in order to allow him to continue, we were obliged to distribute his load among the more robust.

Finally, we reached the summit. It was past 3 o'clock. The guides, anxious to descend before night, placed their loads on the snow and at once left. Mr. Vallot and I remained alone with the guides Michel and Payot. On climbing the last hill I had already had a touch of mountain sickness, and on reaching the summit Mr. Vallot was completely prostrated by it. While he was seated on the ground getting a little strength, I took a glance around me. As Mr. Durier has well remarked, the summit may be compared to a pear divided lengthwise and laid flat, and the stem of which pretty well represents the very narrow part through which we entered. Between this part and the dome, which is scarcely more than sixty feet in diameter, there is a small level spot that we selected as a site for our tent. Aided by the two guides, I had scarcely the strength to set the latter up. After driving stakes into the snow, we firmly secured the tent with a long rope, and then one of the guides prepared the kerosene stove and melted some snow for our dinner. No one had the spirit to arrange the baggage, and, driven by the wind, we entered the tent, swallowed a little soup made of melted snow and prepared bouillon, and lay down upon the ground with our heads resting upon the instrument cases or household utensils as pillows.

Worn out by the efforts that I had made to set up the tent, I went to sleep. Mr. Vallot meantime had regained his spirits, and boldly started out to mount some of the meteorological apparatus on their supports. He had placed a minimum thermometer on the snow, when the cold forced him to come indoors. The canvas flaps that closed the tent were adjusted, and every one slumbered. After a few hours' sleep that I shall qualify as shivering, I awoke, and, fearing that the carbonic acid disengaged by the respiration of four persons might be followed by grave consequences, I called my companions and we decided to do a little aerating. Then we placed the lighted lantern on the ground and resolved to watch it, supposing that it would go out before there was any danger of asphyxia for each of us. But the wind that was raging outside rendered our fears groundless, for it easily traversed the canvas and demonstrated the ventilation by chilling us to the marrow. Toward four o'clock in the morning, Mr. Vallot started from the tent and at once called us. The sun was about rising, and the spectacle was worth the trouble to face the open air for. The thermometer placed upon the snow marked 19° below zero, and explained the cold that we had experienced all night. Mr. Vallot had arranged things with much intelligence. As the summit was everywhere covered with snow whose temperature was 25° below zero, he had provided the tent with two thicknesses of tarred canvas, forming an impermeable flooring, and then placed 1½ inch thick felt cloth thereon. The mattress was hard, but it prevented all contact with the snow. The tent, which was 13 feet square and 5 feet in height, was thus quite comfortable.

In the morning, the general state of our health was better than it was on the day before, but Guide Payot and I experienced violent headaches, and the pulse of each of us beat so quickly that it seemed as if we had a fever. Moreover, the least effort, the least labor, a movement of a few steps, brought on such fatigue that we were forced every instant to enter the tent and sit or lie down.

The rising of the sun was the most wonderful spectacle that it has been given me to behold. In measure as the star of day ascended, it covered the crests of the neighboring mountains with rosy tints. The obscurity in which the multitude of rocky peaks emerging from the snow in the lower regions had been plunged vanished by degrees, and the peaks took on the richest of tints. The clouds under our feet seemed now a rough sea whose billows were pressing against a steep bank, and now a thick veil thrown over the valley still in the dark. Then these clouds, dissolving in the air under the influence of the solar heat, seemed to disappear as if by enchantment, leaving as a trace of their past existence only a thin fog attached to the sides of the mountains. What a spectacle! Excited, filled with enthusiasm, we had forgotten fatigue and uneasiness; but the north wind that was blowing very quickly brought us back from the country of the ideal. It became necessary to arrange our apparatus as soon as possible, in order to begin our observations. Among

FIG. 2.—ENCAMPMENT ON THE SUMMIT OF MONT BLANC.

FIG. 3.—INTERIOR OF THE TENT. 4. ONE OF THE OBSERVERS, WITH MASK.

* Bureau of Statistics, Treas. Dept.

the baggage there was a small table, upon which we placed the large actinometer devised by Mr. Violle. Next, we unpacked the other instruments and mounted them upon a sort of wooden horse.

Every hour, Mr. Vallot and I noted the points of the Arago and Violle actinometers, thermometers, Fortin barometers and anemometer; and every two hours, Mr. Vallot made an experiment with a large actinometer. As this operation took three quarters of an hour, and necessitated an observation from minute to minute, it was the most important and fatiguing one (Fig. 2). At the same hours, Mr. Henri Vallot was to make the same experiments at Chamouny.

The first day was thus passed in work, with but a single diversion—that of a visit at about 11 o'clock from Baron Munch, who had come from Courmayeur, in Italy, and was descending to Chamouny. This traveler was much astonished to find inhabitants at the summit of Mont Blanc, and capable of consoling themselves there with hot bouillon.

The second night was less disagreeable than the first. We had taken the time to improvise pillows that were a little softer than the household utensils, and we were enabled to obtain a less disturbed rest. The tent presented a very picturesque aspect. With much foresight, Mr. Vallot had made us carry along the rubber footgear called "snow boots." After the ascent, made with coarse hunting shoes armed with huge nails designed to prevent slipping, we put on our snow boots over a pair of fur-lined stockings. Owing to this precaution, no one felt cold at the extremities. But what was to be done with our leather shoes? They had been dried in the sun, and we did not wish to put them back in the snow. We decided to hang them at the top of the tent, where a taut rope ran from one end to the other. On this, too, we nightly hung the spectacles that we wore every day in order to remain on the glaciers, as without such precaution ophthalmia might have been brought on. Mr. Vallot, taught by experience, had likewise made us take along skull caps to protect our ears and neck, and canvas masks to protect our face. Rigged out in this way, we had a comical, if not a horrible, aspect. The tent, then, with all these things suspended in it, with the provision boxes, the lighted stove, and smoking evening soup, had a most picturesque appearance (Fig. 3).

The second day was spent in making observations. We scarcely did justice to our provisions. Being always tired, we had no energy, and our appetite did not return to us during our entire stay. The various preserved foods, although very appetizing, hardly tempted our torpid stomachs, and we daily partook of but two soups made of preserved *purees*, in which a little cheese was crumbled. Our drink was always hot coffee. The tea that we had brought along seemed to us on the first day to produce nausea, which was rather attributable to mountain sickness. Nevertheless, the first impression was such that no one was tempted to return to it. The guides, however, drank a little of it.

On the 30th of July, the observations were begun at sunrise. Along about 10 o'clock, the International Hostelry of Mont Blanc, as Mr. Vallot christened our establishment on perceiving some travelers ascending, received a second visit—this time from an Englishman, who, on leaving, was good enough to take some letters in charge dated from the summit of Mont Blanc. We had, too, for the first time since our arrival, a permanent companion. A yellow-beaked black bird, known as the jackdaw, several times alighted within a few yards of us. Fluttering along the crest of snow, it seemed to be inviting us to descend, and, in fact, although the guides had asserted that its presence was a sign of fine weather, it seems that the contrary was the case. Along about two o'clock, huge cumuli began to form on the side of Mont Pelvoux, and then their color changed, the clouds turned black, and, while the weather remained clear over Chamouny, the valley of Aoste and the Alps of Savoy were soon hidden by a terrific storm. The clouds banked themselves up and rose to a great height, and the thunder began to roar. A furious wind soon rose, and we had to enter the tent. It was 4 o'clock in the afternoon. For a moment we had an idea of descending, but, as we did not have time to put all our out-of-door instruments in a safe place, we decided to face the storm. We tautened the ropes of the tent, and heaped snow up all around the latter to consolidate it.

There was then a moment of anxiety. The wind had become very violent. It lashed the tent and made the canvas crack, and the muttering thunder added further to the difficulties of the situation. About 9 o'clock, Mr. Vallot, having gone outside, found himself the object of a curious phenomenon. The summit of the mountain being covered with electric clouds, there were escaping from his garments and head cracking sounds like those observed in experiments on static electricity.

The few hours that we thus passed in the tent, the least apertures in which we were obliged to stop up to prevent the snow from entering, were usefully employed. Mr. Vallot took advantage of the occasion to obtain some physiological diagrams—curves of the pulse, carotid artery, etc.

These observations were useful in dispelling our inquietude of the moment. Finally, about two o'clock in the morning, the storm abated, and, although the wind continued to blow violently, we slept more tranquilly.

The next day, July 31, the date fixed for our return, we decided to continue the observations up to nine o'clock, and then to put everything in the tent and descend as quickly as possible. The guide Michel judged that the descent would be difficult, the tempest during the night having certainly effaced the tracks of travelers of the preceding days. This morning, Mr. Vallot and I felt much better, and we were beginning to get acclimated, but the same was not the case with our guide Payot. A violent headache, complicated with quite a high fever, kept him lying in the bottom of the tent, and we feared for an instant that he could not descend. Our inquietude was intense, and we were already studying a means of dragging him in a blanket, when, along about eleven o'clock, he was fortunately able to get on his feet, and, with much courage, declared that he was ready to carry his haversack. We found that we were heavily loaded. Not knowing whether we could descend on exactly the day appointed, Mr. Vallot had given no orders that porters should be sent to us, and, although it had been decided to leave most of the instruments and baggage in the tent, there were certain things that could not be left to chance. It, therefore, became necessary to divide up the packages.

Finally, after a last glance at the admirable scenery enjoyed at this height, the descent began.

Just as Guide Michel thought, walking was difficult. What is quite rare, the snow, swept by the wind, no longer showed any footsteps, and it became necessary to be constantly cutting out steps in descending the declivities. After a halt at the Grand Plateau, we had a very bad passage. It had rained at this elevation, and the snow had become so friable that in certain places we sank up to the middle of our body. Moreover, in the steep places, where it is necessary to descend in zigzag, the snow slipped under our feet, and it was only through using great precaution that, crossing the crevasses under the Small Plateau, we reached the Grand Mulets. Here, after a good meal, and in a more clement temperature and denser air, we rapidly recovered our forces, and after changing the papers of our registering apparatus, we again got under way.

Along about 7 o'clock, we finally reached Chamouny, where we found ourselves the object of a reception that abashed us. The mayor, at the head of the municipal authorities and a deputation of guides, presented us with piles of flowers, and offered us welcome in a few stirring words from the midst of an enthusiastic crowd that repeatedly cheered us. This instant made us forget all the fatigue and dangers of the trip.

The object had been attained, then. For the first time, a few days had been passed on the summit of the giant of mountains, and Mr. Vallot had once more shown that boldness, coupled with a very developed spirit of organization, permits of conquering difficulties and of increasing the sum of our scientific riches.

I have not here spoken of the results of the expedition. These will form the subject of a report after the data collected have been classified, studied, and discussed. I may say, however, as an immediate conclusion, that it is quite possible to live and work at such altitudes, but under very poor sanitary conditions. The true danger resides in the storms, which arise unexpectedly, and which may change into violent tempests in which the best devised arrangements would count for nothing more than a wisp of straw.

Since the ascent of July 27, Mr. Vallot has again visited the summit to put some registering apparatus in order. His companion on this occasion was Mrs. Vallot, who is now one of the few intrepid ladies who have reached the summit of Mont Blanc.—*F. M. Richard.*

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